POWER

Volume 57 New York, February 6, 1923 *Number* 6

What is Universal Well-Being?

The problem of universal well-being offers a challenge and a call to duty that the engineer may not refuse.—DEAN DEXTER S. KIMBALL.

WHAT is the universal well-being that man has sought all through the ages and is seeking still?

If the engineer is called upon to solve the problem, the first thing that he will insist upon is its definition.

Not wealth, for the worth of wealth is simple ability to command service, and if wealth were universal we should all be commanding service of one another and starving to death.

Not power, for power implies subjects, and this well-being is to be universal.

Is it not simply to so order affairs on this little island in space that every living being upon it, at least of the human kind, may cover his little span of life with the most of gratification and the least of sorrow or pain?

The resources of the earth are such that if the efforts of the race were intelligently directed there could be enough food, clothing, fuel and shelter provided to keep everybody nourished and comfortable with a few hours work per day by each able-bodied person.

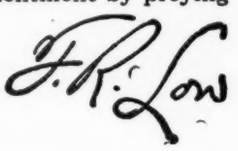
The engineer has made this number of hours smaller, or multiplied the things that the race may have for its "well-being" over and above the bare necessities by providing artificial power and the machinery by which it does the work that would otherwise have to be done with human hands.

There must be a universal realization of the fact that what one wants he has got to work for. Every man should be insured, not a living, but a chance to make a living. And so comes in the idea of work, industry, as one of the essentials of universal well-being.

The man of exceptional talents will be able, by his inventive genius, by his executive ability, to make the returns of labor greater, to adapt new materials to the use of man, to increase man's mastery of his environment; to cure the sick, eradicate disease and allay human suffering. And so comes in the idea of service, race service.

The engineer can do much to guard man against natural catastrophes or to bring him quick relief from their consequences. Fire and famine and many floods are preventable, but man's greatest enemy is man. War has done more to prevent the universal well-being of man than all the untoward natural agencies together. There can be no universal well-being until it is realized that it can be had quicker and easier by working for it than by fighting for it, by creating for oneself rather than trying to take away by force or cunning what another has made.

Work, interested, intelligent, efficient work; service, public service, race service, freely, devotedly given for the general good and the restraint of universal condemnation upon that spirit of acquisitiveness or exaggerated self-interest whether of an individual, a corporation or a nation which leads to the disturbance of the world's peace or domestic contentment by preying upon the industry of others — these are some of the essentials of Universal Well-Being.



Plant of Brunswick-Balke-Collender Co. Muskegon, Michigan

COMPOUND-ENGINE non-condensing plant in which exhaust steam is used for process work, dry kilns and heating. An approximate balance between power steam and exhaust steam requirements insures high operating economy. Water raised by air lift. Special coal and ash handling. Thirty-cycle current generated.

IN 1905 the Brunswick - Balke - Collender Co. erected a plant at Muskegon, Mich., for the manufacture of billiard tables, bowling alleys, phonographs and, quite recently, automobile tires. Nearly every year from its inception additions were made to the works, and as is usual in a plant built in this way, current for light and power was purchased and the steam needed for process work and heating was generated in a boiler plant operated by the company. With the addition of a tire department in 1917 it was evident that a large increase in boiler capacity would be necessary, and at the same time it was decided to co-ordinate the power and steam demands. In other words, past operating data had shown that from the steam needed the year around for the dry kilns and rubber process and for heating in winter, sufficient electrical energy could be generated to meet all power and lighting demands. Combining the services in this way would insure economies ranging in the vicinity of 60 to 70 per cent and at a cost but little greater than that for the steam alone under the former method of operation.

It was therefore decided to remodel the boiler room by installing stokers under boilers that formerly had been hand fired and adding boiler units to meet the greater demand for steam while maintaining service at all times.

As operation necessarily must be non-condensing against a back pressure of 3 to 5 lb., and with use for practically all the exhaust steam during eight months of the year, engines were selected as prime movers. To balance the two services, the engines must be economical, and this was particularly desirable during the summer months, when the heating system, having an equivalent of 200,000 sq.ft. of direct radiation, was off. The surplus of exhaust steam during this period was not considered sufficient to warrant the in-

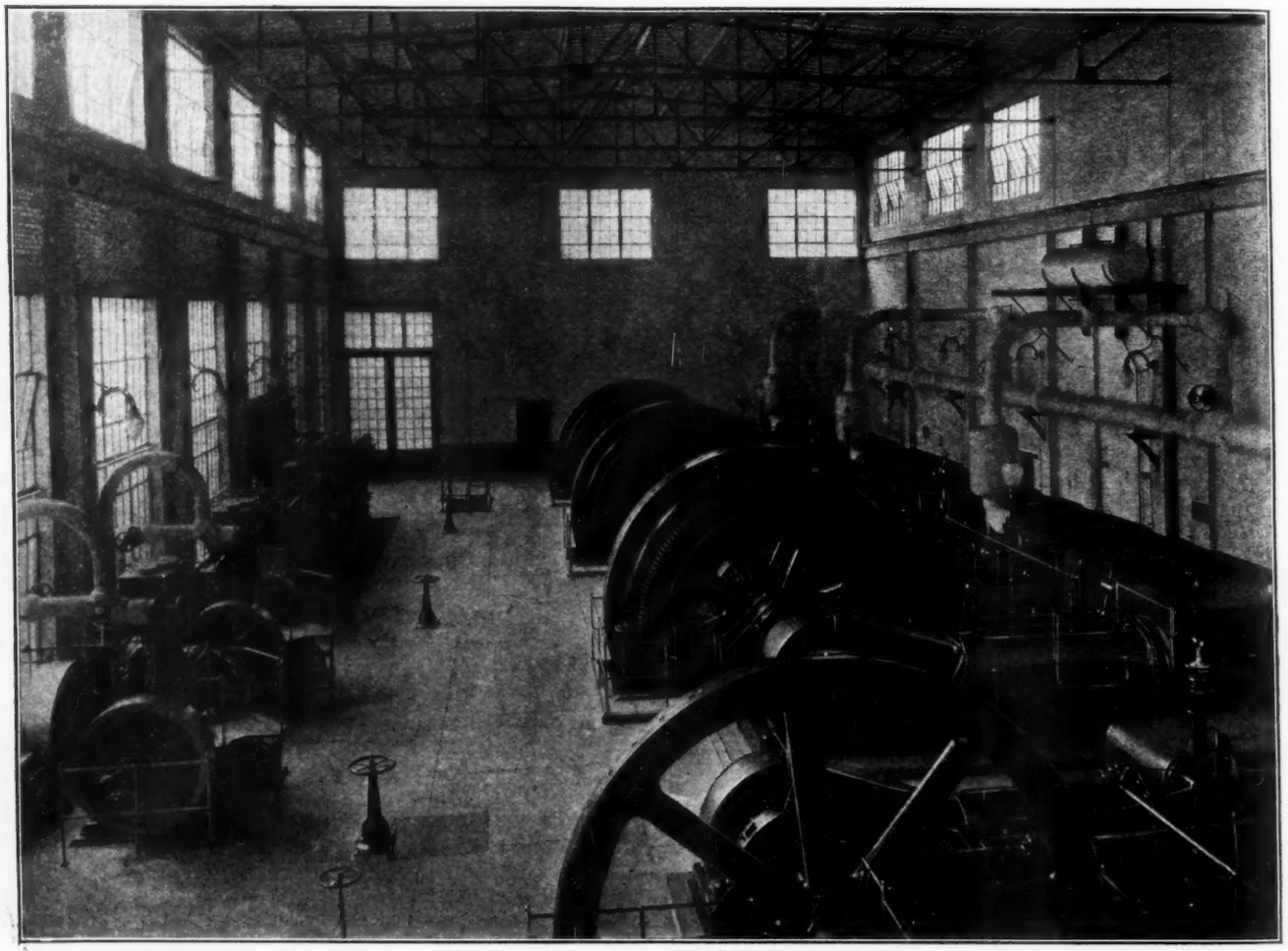


FIG. 1—ENGINE ROOM OF THE BRUNSWICK-BALKE-COLLENDER COMPANY

stallation of condensers. Cross-compound Corliss engines were therefore installed in the plant. Under the operating conditions existing, 160-lb. gage pressure and 3-lb. back pressure, these engines have a guaranteed steam rate approximating 27 lb. per kilowatt-hour at the switchboard. They are heavy, substantial machines with a speed of 100 r.p.m., well adapted to withstand the service at a low cost for upkeep. Three 1,200-kw. units give flexibility in handling an electric load ranging at the present time from 800 kw. at night to 2,000 kw. during the day. All auxiliaries in the station are steam driven with the exception of the motors driving the coal- and ash-handling equipment.

In the remodeled boiler room, measuring 90x100 ft., nine boilers are now in place. Six of the older units, each containing 4,000 sq.ft. of steam-making surface, are arranged two per battery on one side of a 25-ft. central firing aisle and three new boilers with 6,000 sq.ft. of surface are placed on the opposite side, as indicated in Fig. 2. Of the older boilers two are equipped with Dutch ovens to burn the wood refuse from the manufacturing plant. The other four had been hand-fired with coal, but it was decided that they should be equipped with stokers and complete coal- and ash-handling systems provided.

As the fuel for the plant is lump coal from West Virginia and Ohio, stokers of the underfeed type with steam-operated ash dumps were selected. The limited width of the older boilers allowed the use of only four retorts. Before starting the installation, certain preliminary work was necessary. It was decided to shore up the boiler-room floor, excavate a basement and then lower the floor three feet to provide the extra headroom needed by the underfeed stokers over the hand-fired installation. In this way headroom of nine feet from the floor to the bottom of the front tube header was secured. To maintain service, the stokers had to be installed one by one and put into operation before work could begin on the next unit.

After the older section of the plant had been remodeled, the three larger boilers were installed on the opposite side of the firing aisle. The settings were made wide enough to accommodate seven retorts, and large furnace volume was provided. In both cases the boilers are of the horizontal type, vertically baffled. A radial-brick stack 11 ft. in diameter and 190 ft. high

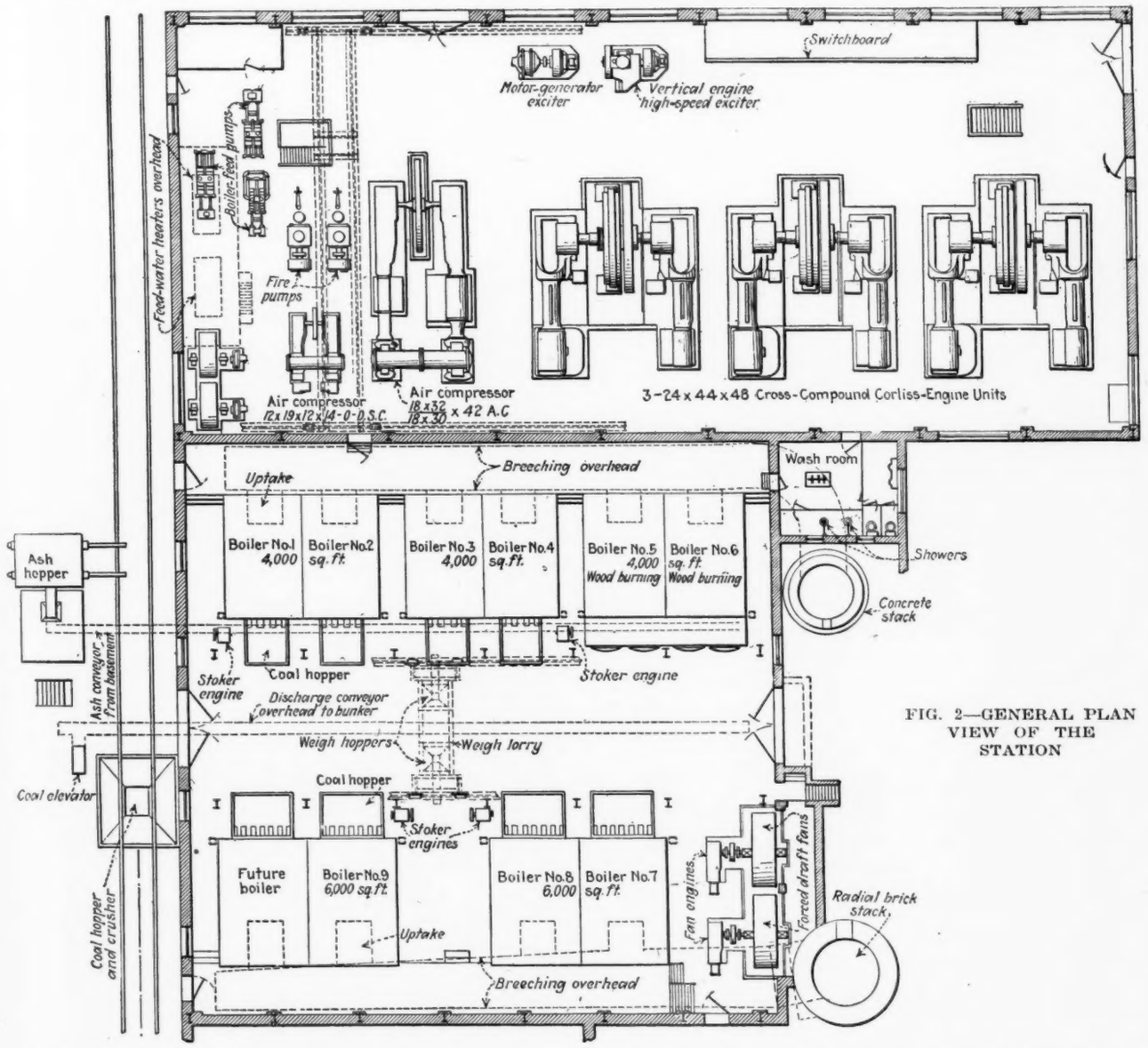


FIG. 2—GENERAL PLAN VIEW OF THE STATION

serves the new boilers, and a reinforced-concrete stack 9 ft. in diameter and 155 ft. high carries away the gases from the older boilers. An operating steam pressure of 160 lb. gage, with no superheat, is carried, and

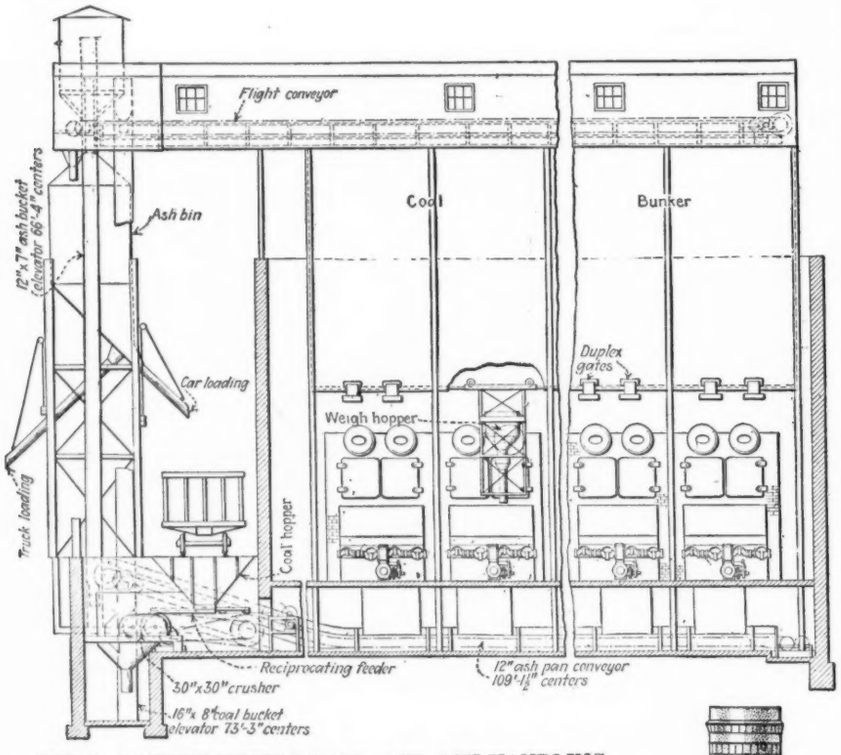


FIG. 3—LAYOUT OF THE COAL- AND ASH-HANDLING EQUIPMENT

it is the practice to operate the boilers in the vicinity of 160 per cent of rating, this having been found to be the most economical load when considering maintenance as well as efficiency.

ing boilers carry the remainder of the load, the demand calling for four and sometimes five of the seven stoker-equipped boilers. The wood refuse, shavings and sawdust, is drawn from the machines in the wood-working department by booster fans and delivered to an 18x24-ft. storage bin on the roof of the boiler house. A drag conveyor delivers the contents of the bin into hand-controlled spouts discharging into the tops of the Dutch-oven furnace serving the two wood-burning boilers.

Vertical engines, one at each end of a stoker shaft in the basement, drive the stokers in either row of boilers, the second engine in each case being a reserve unit. Between the engines and the shaft and also between the shaft and the stoker gear boxes, roller chains are employed.

To each group of boilers two forced-draft fans supply the air for combustion. The fans, as well as the stoker engines, are mounted on the boiler-room floor. Either unit of the fan installations is sufficient to supply the full demand from its respective boilers. In the case of the older installation the fans are turbine-driven and are controlled by chronometer valves in the

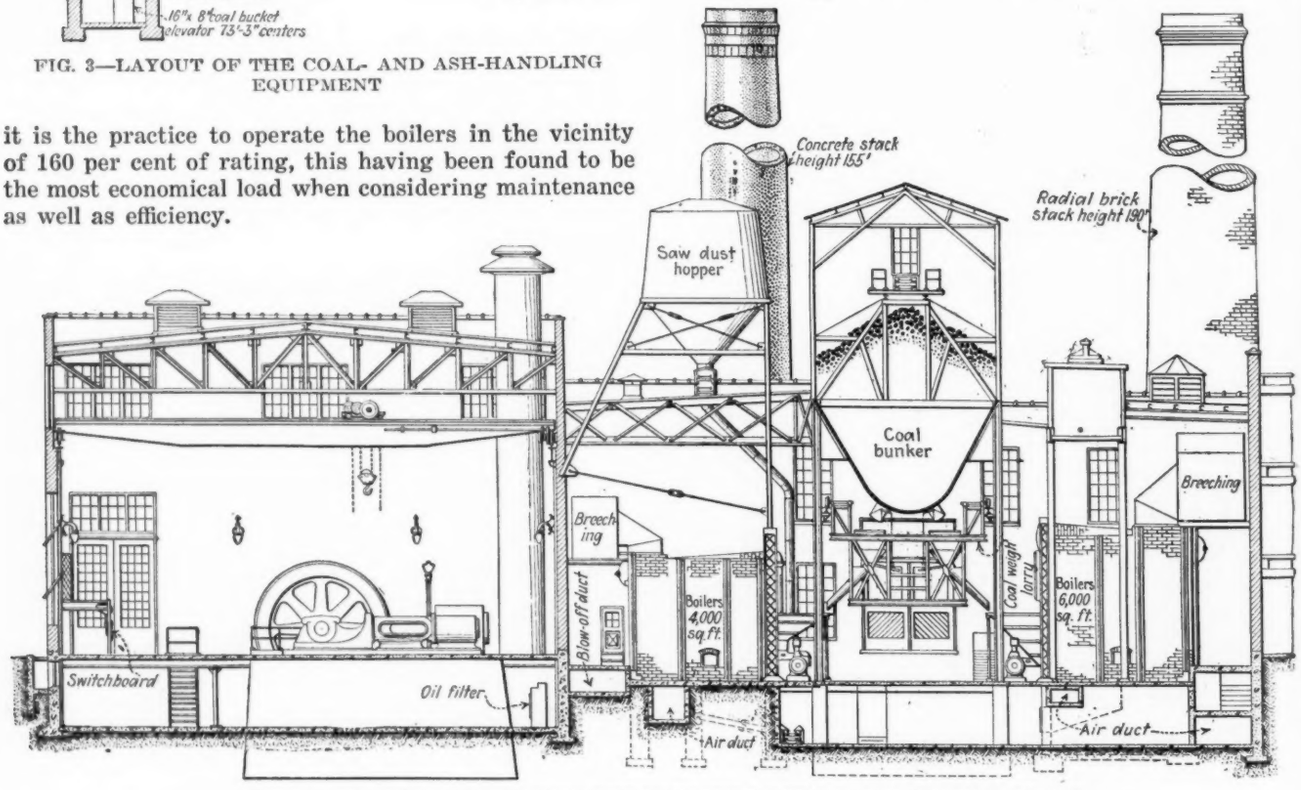


FIG. 4—SECTIONAL ELEVATION THROUGH THE BOILER AND ENGINE ROOMS

The two refuse-burning boilers are operated night and day. When one of them is down for cleaning, there is sufficient storage capacity to hold the refuse until the boiler can be placed again in service. In this way the refuse is kept cleared up and as much steam as possible is generated from waste fuel. The coal-burning

steam supply lines which are manipulated by a single pressure regulator. The capacity of each fan is 48,000 cu.ft. per min. against 6-in. static pressure. Horizontal high-speed engines drive the other set of fans, each rated to deliver 50,400 cu.ft. per min. against 4½-in. static pressure. The fan speeds are 1,800 and 270 r.p.m.

Water to supply the entire plant comes from a single deep-well on the premises. As the supply is principally seepage through the sand from Lake Michigan, one-half mile distant, the water is of exceptionally good quality and requires no softening for boiler use. An air lift brings the water to the surface and discharges it into a large concrete settling basin from which all services are drawn. The presence of so much sand made the use of an air lift desirable. Two machines have been installed to maintain this service as well as to furnish the compressed air needed throughout the works. One unit having capacity to supply 4,000 cu.ft. of free air per min., has compound non-condensing steam cylinders, 18x32x42 in., and two-stage air cylinders, 30x18x42 in., supplying air at 100-lb. pressure. The other machine, a twin steam, two-stage air compressor, has capacity to deliver 600 cu.ft. of free air a minute. As exhaust steam from both machines is utilized, this method of raising the water should prove highly economical.

From the heating and drying systems, vacuum pumps bring back the returns to either one of two open feed-water heaters rated at 110,000 lb. each. Much of the feed water therefore is condensation, but whatever makeup is needed comes from the calenders in the rubber plant, at temperatures of 150 to 200 deg. F. As

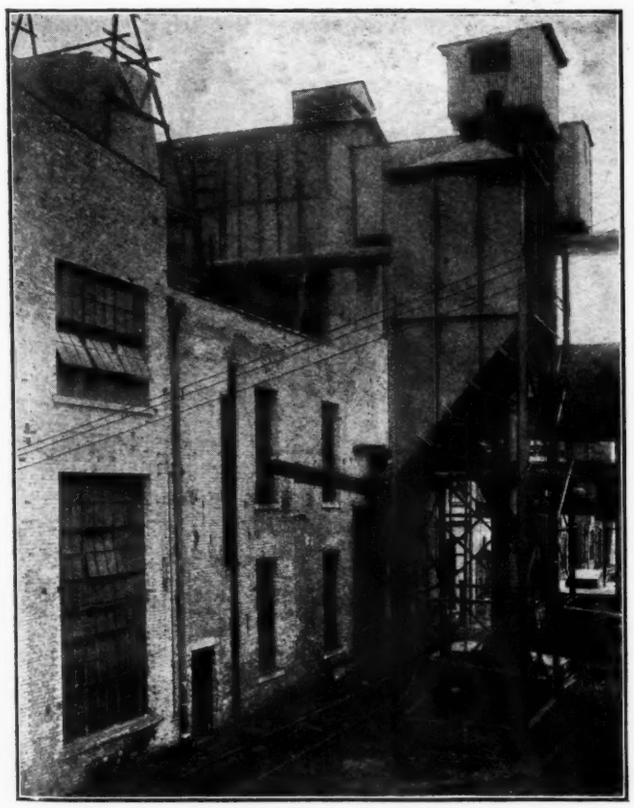


FIG. 5—EXTERIOR VIEW OF THE BOILER ROOM, WITH ASH TANK IN THE FOREGROUND

there is a great abundance of this water, the amount required for makeup is admitted to the heater under float control. From the heaters the feed pumps deliver the water to the boilers under the control of pump governors and individual regulators at the boilers. Of the three feed pumps installed, two are of the steam-driven duplex type and the other is a large centrifugal turbine-driven pump. Other equipment in the pump-room consists of the two vacuum pumps previously mentioned, a centrifugal process pump having a capacity of 1,000 gal. per min. and two underwriter duplex steam-driven pumps installed for fire protection.

For the handling of coal and ash, two separate and distinct conveyor installations have been provided. The coal-handling installation consists of a track hopper

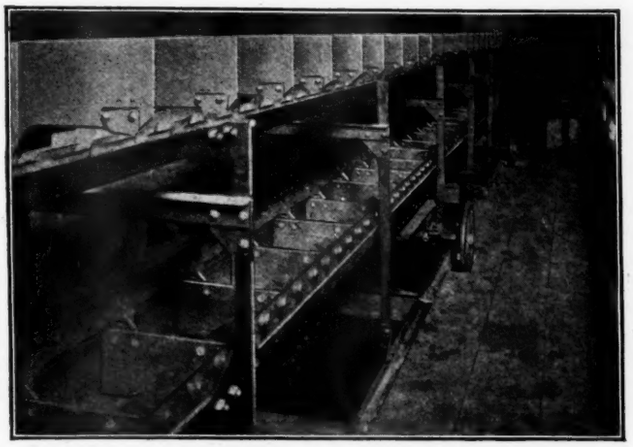


FIG. 6—FLIGHT CONVEYOR OVER THE COAL BUNKER

reciprocating plate feeder, crusher, bucket elevator, flight conveyor and overhead storage bunker. The ashes are handled by a cast-iron pan conveyor and a bucket elevator delivering to a storage bin.

Coal is received in bottom-dump cars which discharge into a 12x12-ft. steel track hopper provided with a reciprocating plate feeder which is arranged to discharge the coal either into a 30x30-in. double-roll crusher or through a bypass directly into the boot of a bucket elevator. The latter, which has a vertical rise of 73 ft. between centers and is equipped with 16x8-in. steel buckets, discharges onto a flight conveyor. The flights are spaced approximately 18 in. apart. In the bottom of the conveyor trough there is a series of gates which can be opened or closed at will to discharge the coal at the desired point into an overhead storage bunker of 1,400 tons capacity. The transfer from the storage bunker to the stoker hoppers is made by a self-propelling traveling weigh-larry which has a 2,000-lb. hopper on either side to serve each row of boilers.

About 300 ft. from the boiler room yard storage for 10,000 tons of coal has been provided. To this location the railway cars are switched by means of a steam hoist placed at the end of a track hopper from which the coal is taken by a belt conveyor and delivered to storage. By means of the same belt conveyor the coal is reloaded for delivery to the boiler house.

From the pits beneath the stokers the ashes are raked into the cast-iron pan conveyor previously mentioned. This conveyor, consisting of 12x12-in. overlapping cast-iron pans is supported on steel tracks. It carries the ashes to the end of the building where the conveyor rises on a slight incline and discharges into the boot of a vertical ash elevator measuring 67 ft. between centers and fitted with 12x7-in. buckets. From the bucket elevator the ashes are discharged into a rectangular steel storage bunker having a capacity of approximately 40 tons. The hopper bottom of the bunker is fitted with two spouts, one delivering to trucks or wagons and the other to railroad cars.

With the labor-saving equipment installed to handle coal and ash, one man is able to unload all the coal from the railway cars into the overhead bunker and to move all the ashes from the 60 to 75 tons of coal burned per day.

To insure operation at high economy, complete records are kept of important operating data. The coal is weighed as it is delivered to the stokers and the feed water is measured in a V-notch meter. Each boiler has its steam-flow meter, and there are other meters to record the flow of steam to different departments of the works. Recording thermometers show the temperature of the flue gases and of the boiler feed water. Other recording gages show the steam pressure, back pressure, the air pressure and the vacuum on the heating and drying systems, as well as the pressures in the process and sanitary water systems. The boilers have 3-in-1 draft gages as well as the usual indicating instruments common to a plant of this type.

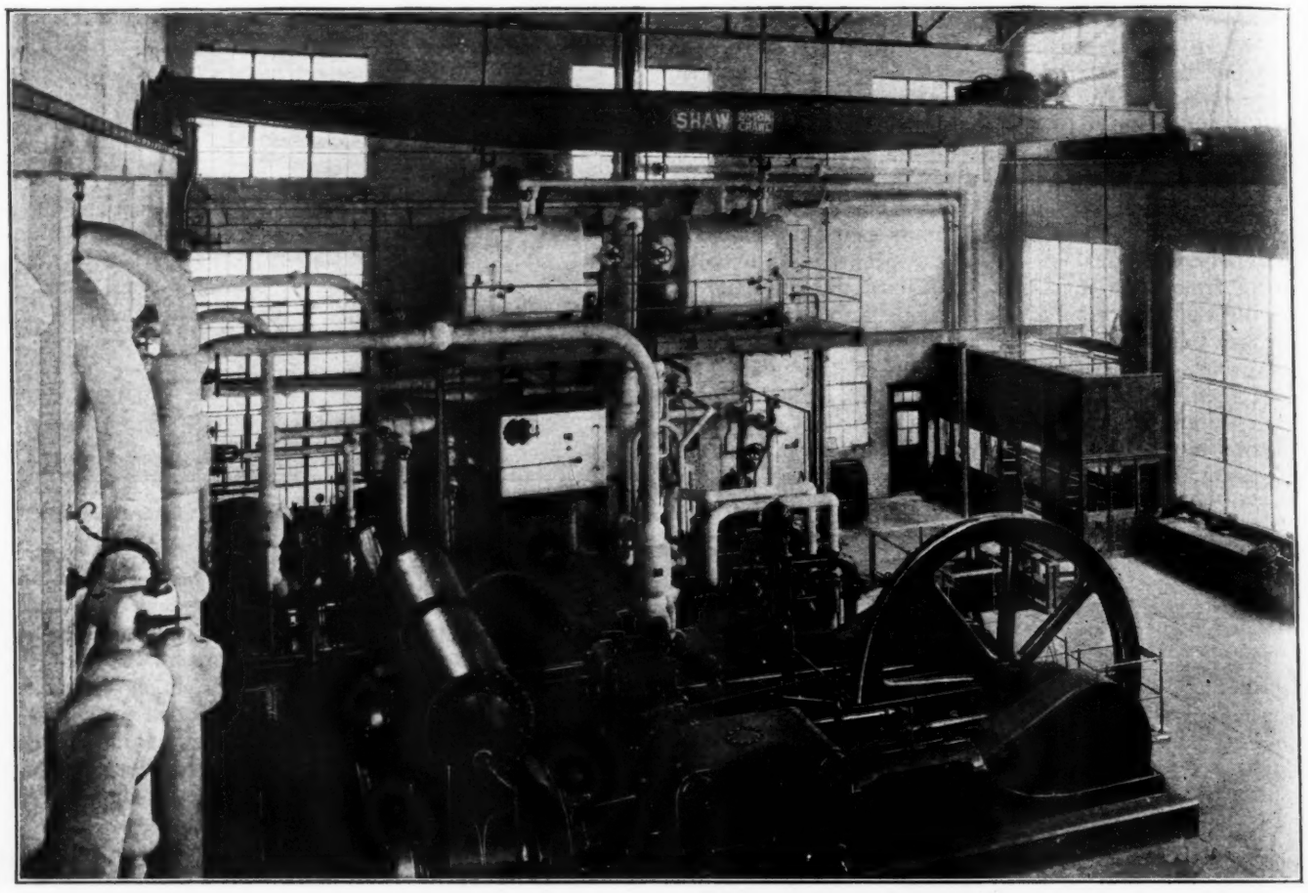


FIG. 7—AIR COMPRESSOR, PUMP AND HEATER INSTALLATIONS

As indicated in Fig. 1, the engine room has been made attractive, the construction being of brick and reinforced concrete. In plan the room measures 90x150

DATA ON MECHANICAL EQUIPMENT BRUNSWICK-BALKE-COLLENDER CO., MUSKEGON, MICH.

BOILERS AND AUXILIARIES

Boilers, 4 hor. water-tube, 4,000 sq.ft.	Kroeschell Bros. Co.
2 hor. water-tube 4,000 sq.ft.	Babcock & Wilcox Co.
3 hor. water-tube 6,000 sq.ft.	Kroeschell Bros. Co.
Stokers, 4 underfeed, 4 retort	American Engineering Co.
3 underfeed, 7 retort	Sanford Riley Stoker Co.
Stoker drives, 2-5 x 7 vert. steam engines	Troy Engine & Mach. Co.
2-7 x 7 vert. steam engines	B. F. Sturtevant Co.
Fans, 2 forced-draft 48,000 cu.ft.	Green Fuel Economizer Co.
Drive 49-hp. Terry turbine	
Fans, 2 forced-draft	B. F. Sturtevant Co.
Drive, 10x12-in. Ball engine	
Stack, 1 radial brick	Alphons Custodis Chimney Const. Co.
Stack, 1 reinforced concrete	General Concrete Const. Co.
Heater, 2 feed water 120,000 lb.	Platt Iron Works
Meter, 1 V-notch 250,000 lb.	H. S. B. W.-Cochrane Co.
Feed pumps, 3 duplex 14x9x12 in.	Dean Bros. Steam Pump Works
Feed pumps, 1 centrifugal steam-driven	De Laval Steam Turbine Co.
Feed-water regulators (Copes)	Northern Equipment Co.
Soot blowers	Diamond Power Specialty Corp.

COAL- AND ASH-HANDLING EQUIPMENT

Conveyor, flight, motor-driven	Stephens-Adamson Mfg. Co.
Bucket elevator, motor-driven	Stephans-Adamson Mfg. Co.
Crusher, 2 roll 30x30 motor-driven	Stephans-Adamson Mfg. Co.
Plate feeder, 30x108 in. motor-driven	Stephans-Adamson Mfg. Co.
Bunker parabolic steel, 1,400 tons	Hansen & Alcock Co.
Weigh Larry traveling	Stephens-Adamson Mfg. Co.
Elevator (ashes) bucket, motor-driven	Stephans-Adamson Mfg. Co.
Conveyor (ashes) cast-iron pan	Stephans-Adamson Mfg. Co.

ELECTRIC GENERATOR EQUIPMENT

Generators, 3, 1,200 kw.	Westinghouse E.ec. & Mfg. Co
440-volt three-phase 30-cycle 100-r.p.m.	
Drive, cross compound Corliss 24x44x48 in.	Bates Machine Co.
Exciter, 100-kw. 125-volt	Western Electric Co.
Drive, 150-hp. high-speed vert. engine	Bates Machine Co.
Exciter, 100-kw. 125-volt	Western Electric Co.
Drive, 150-hp. motor	
Gravity oiling system and filter	W. W. Nugent Co.

MISCELLANEOUS EQUIPMENT

Traveling crane, 20 ton capacity	Shaw Elec. Crane Co.
Vacuum pumps, 2 steam, 10x14x16-in.	Worthington Pump & Mach. Corp.
Service pump, 1,000 gal. per min. centrifugal motor-driven	American Well Works
Fire pumps, 2, duplex 1,000 gal. per min.	Fairbanks-Morse Co.
Air lift systems, 250 gal. per min.	Sullivan Machinery Co.
Air compressor 4,000 cu.ft. per min. compound steam, two-stage air	Allis-Chalmers Mfg. Co.
Air compressor 600 cu.ft. per min., twin steam two-stage air	Chicago Pneumatic Tool Co.
Valves, steam and water	Crane Co.
Valves, blowoff	Scully, Steel & Iron Co.
Valves, safety	Crosby Steam, Gage & Valve Co.
Steam traps	Anderson Co.
Water columns	Reliance Gage Column Co.
Draft gages	Precision Instrument Co.
Flow meters	General Electric Co.
Recording gages and thermometers	Taylor Instrument Co.
Pump governor	Mason Regulator Co.
Pipe covering	Johns Manville, Inc.
Piping contractor	Wm. A. Pope

ft. and the elevation to the ceiling is 75 ft., giving an abundance of room for an overhead traveling crane and the roof girders. The photograph just referred to shows the three generating units of which the prime movers are cross-compound, non-condensing Corliss engines with cylinders 24x44x48 in., the speed being 100 r.p.m. These dimensions give cylinder ratios of 3.36 to 1—favorable proportions for non-condensing operation. The alternating-current generators of these units, each of which is rated at 1,200 kw., are unusual in that the frequency is 30 cycles, which is prevalent in this section of the State of Michigan. The works had been equipped with motors of this frequency, and in order to avoid any change in the power equipment, the generators were designed for the conditions existing.

Excitation for the main generators is supplied by two exciter units, each rated at 100 kw. One machine is driven by a high-speed vertical engine making 275 r.p.m., and the other is motor-driven at a speed of 300 r.p.m.

Lubrication in the engine room is effected by a gravity oiling system consisting of a filter having a capacity for 500 gal. an hour, an overhead storage capacity of 1,000 gal. and two steam-driven pumps, each capable of delivering 500 gal. an hour. Forced-feed oil pumps lubricate the engine cylinders.

The switchboard, which is made up of 19 panels, is standard in construction and instrument equipment. Each circuit has its automatic circuit breaker and ammeter and recording kilowatt-hour meters are provided for each department of the works.

Credit for the design of the plant is due the engineering department of the company and to J. W. Lyons, of Chicago, who acted in a consulting capacity.

Boiler Inspecting—I

By James F. Hobart

THIS article describes in detail a typical uniform and equipment and is the first of a series of seven articles treating on the different phases of boiler inpection for the information of the engineer.

THE engineer who is to inspect steam boilers for possible defects that may cause accident or that may eventually reduce the pressure carried or shorten the life of the boiler, should prepare for this work in two ways. Mentally, he must fit himself to seek and find any defects with which a steam boiler can be afflicted, to know these defects when he sees them and to *sense* them when he has really not seen them plainly. Almost intuition is the work of some boiler inspectors.

The inspector must have education enough to "figure" a steam boiler and that means to calculate the strength of the shell, heads and tubes and to determine the amount of bracing and staying necessary; in fact, he must be able to design a first-class boiler as far as making the necessary calculations are concerned.

In addition to the necessary amount of education, he must possess certain mental characteristics or he will not be worth much as a boiler inspector. For instance, one having the qualifications that make a good judge might make a mighty poor inspector. His work would probably be well done and accurately; but it would take him forever to do it! He would have to search out, weigh and consider every point and think it through from beginning to end before rendering a decision.

On the other hand, the engineer who had the making of a first-class salesman would make a good boiler inspector. He would see everything there was to see and sense the rest in and about the boiler. He would have the "push" to enable him to see things and sense their meaning, their causes and their effect without preparing a congressional discussion of each point involved.

The inspection, to be of any value, must be thorough. The inspector must "do the crawling," and he must be equipped therefor. He must wear a sort of combination overalls and jacket which will permit the utmost freedom of movement and still keep dirt from the person as much as possible.

For the inspection of new boilers any suit will answer, as that work is not particularly dirty, but the

UNIFORM, AND EQUIPMENT NECESSARY WHEN INSPECTING BOILERS

inspector of old boilers must be able to crawl into the combustion chambers, into the furnace and into the back connection as well; also to go inside of wet boilers.

A Good Inspection Suit

Union overall suits are now to be had ready made, and some of those used by automobile repair men will answer very well. It is necessary that such suits be strong and whole, well made of material that will not permit dirt to pass through its weave. The suit must fit snugly, as a loose garment will cause trouble when the wearer slides through manholes or cramped passages in a boiler setting.

An inspector's suit must not be too tight, or the wearer will be cramped in his movements. In the illustration is shown a good form of inspection suit which may well be made to order.

Care should be taken to have the hood *A* (shown in detail at *E*) and suit *B*, fit and button closely so that no dirt can get into them. The hood should be cut to fit tightly around the face; in fact, a new hood should fit so tightly as to be uncomfortable when first put on, but it will soon stretch. The suit should be made to button snugly down in front and the buttons should be placed close together. The side of the suit on which the buttons are sewn should be made to project at least four inches past the line of buttons. The cloth thus placed, serves as a lap which stops most of the dirt that might otherwise find its way through between the buttons.

The legs and sleeves of the inspector's suit should be made of ample length so as to reach well against the ankles and hands. The sleeves should be made to button closely against the wrist, and the split in the sleeve should be made with a flap or a tongue which will stop any and all dirt from entering the sleeve.

The legs should be made barely large enough to enable the engineer to push his shoes through them, and the length of legs should be such that they reach to the ground when the engineer stands erect. Unless the suit legs are made of ample length, the engineer will find his movements handicapped when he tries to "jacknife" himself into some of the positions necessary when crawling.

When the legs of an inspector's suit are too short, not only does the wearer find dirt creeping into his stockings, but the strap with which the legs of his suit should be closed, will pull off of the suit or perhaps hold it so securely that—as often happens with a somewhat worn suit—the cloth will rip or tear away. Therefore make the suit legs of ample length to reach to the floor and there will be little trouble in closing the bottom of the legs against dirt.

Ankle Straps Required

As shown at *C*, the lower end of each leg is securely closed by a strap, which is shown in detail at *D*. The straps are buckled snugly around the ankles and hold the suit legs secure against dirt and prevent them from pulling upward no matter what contortions the wearer may go through while crawling.

Some engineers may prefer a strap around each wrist, but this is not necessary, for with the tongue in the sleeve, as previously described, and with well-fitted buttons and buttonholes, the sleeve may be made to fit so tightly around the wrist as to hurt, especially with a new or freshly laundered suit.

The detail of the hood is shown at *E*. This should be made with an ample cape and should fit the head and face tightly and button closely down over the throat and to the lower edge of the cape.

Boiler Inspection Tools

The principal tools used when inspecting a boiler—namely, some kind of a light and a small peen hammer—are also shown. What to use for a light is a much-discussed question among boiler inspectors. You may use an electric torch or flash light, but you will probably find the price of battery renewal large if not prohibitive. You may rig up a flexible electric cord and a small incandescent lamp set in a protective cage, and attach the cord to some convenient light socket. This forms about the best lighting combination possible, but some boiler rooms are not fitted with electric-light current and then the engineer cannot make use of his electric-light extension. After all has been said, about the most reliable light for boiler inspection is the time-honored candle, as pictured in the hand of the inspector. Candles can be procured almost anywhere, and they are always reliable and ready for instant work. No matter what light may be available, always have a candle or two at hand.

A small hammer is a most important part of the inspector's outfit. In fact, a boiler inspector would be utterly lost without his hammer, for the reason that everything he looks at he is likely to strike with his little hammer that his ear may aid his eye in detecting imperfections.

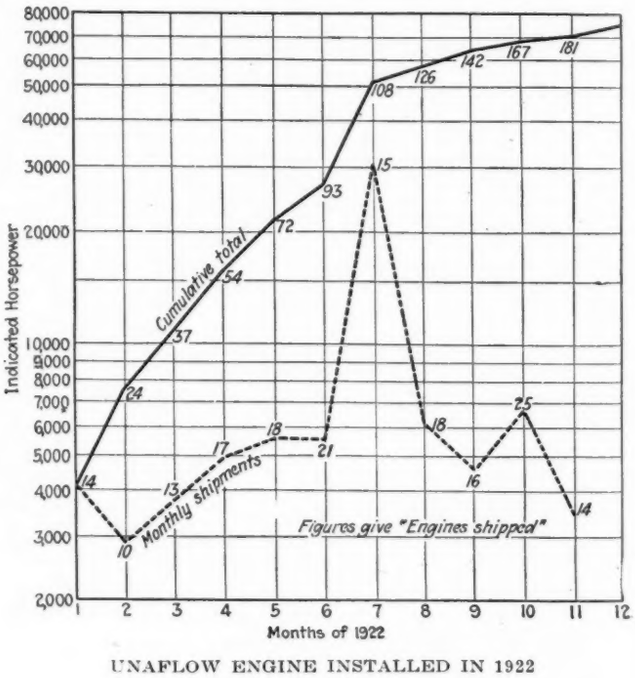
A hammer similar to that shown at *F* is much liked by boiler inspectors. The hammer head should weigh about six or seven ounces, and the handle should not be more than fourteen or fifteen inches long. The writer prefers a "cross-peen" hammer as shown, for the reason that such a peen may be used hoe-like for cutting out scale and other deposits in order to get to the boiler plates under certain conditions. It is well to keep the peen ground to a sharp edge. Some inspectors, however, prefer "hatchet-peen" hammers.

In addition to the hammer, have at hand a small cold chisel and a pair of small pliers, a small flat or three-cornered file and a small screwdriver. The last-named tool is necessary for adjusting steam gages, but a screwdriver with a stem not over $\frac{1}{8}$ in. in diameter is hard to find in a boiler room and should be provided by the inspector.

The engineer should also provide himself with a small pressure gage for use when testing steam gages and there should also be a "jack" for removing the hand or pointer preparatory to adjusting the pressure gage.

Unaflow Engines Installed in 1922

In the June 20, 1922, issue of *Power* were published a number of charts on the growth of the unaflow engine industry. In the chart herewith are shown the cumulative horsepower of unaflow engines sold during 1922, as well as the monthly shipments. The chart is laid



UNAFLOW ENGINE INSTALLED IN 1922

out on a logarithmic scale which enables one to discover if the rate of increase is constant. It will be noticed that there was a marked increase in horsepower shipped during July. This was due to the installation of a large rolling-mill engine of 25,000 i.hp.

While in previous years the central stations were the largest purchasers of unaflow engines, during 1922 the industrial demand overshadowed that of the central station. The iron and steel mills, which up to 1922 took only 10 per cent of the total engines sold, in 1922 purchased 30 per cent of the year's production.

Removing Sand from Water Going to Hydro-Electric Turbines

By John S. Carpenter

As applied to hydro-electric plants the sandbox is a feature often slighted both in appreciation and design. A comparatively small content of sand or silt passing through a turbine at high velocities can cause an unbelievable amount of cutting in a runner, gates and running joints and too often it is only after a heavy repair bill is presented that the sand elimination is given serious thought. In the writer's opinion the only thing comparable is the sand blast used for cleaning castings. Contrary to some opinions the rounded, smooth sand does not appreciably damage the running joints and runner vanes. Neither does water carrying alluvial soils in suspension cause trouble unless the particles are of appreciable size. It is the sharp, quartz variety of sand and the glacial silt that make the trouble.

As far as the writer knows, but two methods of elimination are in use: First, centrifugal and gravity; second, gravity alone. The centrifugal method has been used to only a limited extent and can hardly be seriously regarded for plants of any magnitude. In brief, the centrifugal method consists in causing the water to make a sudden turn from a high to a low velocity, whereupon much of the sand content will be deposited by gravity. Then the water can be gradually accelerated.

In the gravity method two principles are involved, similar to the foregoing: First, the water must be quickly retarded in its flow; this is best accomplished by a sudden enlargement in the area of the channel. The sand will then be precipitated, as the transporting power of water varies, it is claimed, as the fifth power of the velocity. Having precipitated the sand, the water must now be very gradually accelerated to the pipe line or canal velocity. The more fully these two requirements are met the better will the results be.

The rate at which the water is accelerated should be carefully considered. If this rate is too fast, the sand will be picked up again and the work will have been in vain; on the other hand, if the rate is too slow the cost of the concrete work will be excessive. So far as the writer knows, no experiments have been carried out to determine the maximum rate of acceleration permissible. We will therefore have to be guided by observations on forebays that are known to be successful. If one knows the rate of acceleration permissible, then the length in which the acceleration can be accomplished will also be known. Comparing the rate of area decrease in the concrete flume to that in a circular pipe, a large sandbox known to be successful has a rate of acceleration corresponding to a circular taper pipe with a 10-deg. included cone angle. This sandbox handles fine, sharp silt and small gravel at times and removes all but a very fine precipitate.

The next and an important problem is to get rid of the precipitated sand. This must be accomplished without interrupting the flow of water. The best arrangement known to the writer employs a blowing-down arrangement with a number of blow-downs. In the section of the forebay, where the greater part of the sand is to be precipitated, the bottom of the channel should be made with a V-shaped section so the sand can gravitate to the center. The topography of some localities may make it desirable to have the sand blown off at the sides of the flume, in which case the section of the flume would have to be something similar to a W-shape, having a high part in the center to deflect the sand to both sides. The length of the flume or forebay should be divided up into several sections so that the sand can be gathered into pockets and then blown out through a 10- or 12-in. sand gate. Were the length of the forebay not divided as described, only small cones of sand would be blown out when the sand gates were opened.

As to the velocities to be used in the enlarged portion of the forebay where the sand is to be dropped, in general it can be said the slower the better, and 0.5 to 0.75 ft. per sec. will give good results.

Using a Lubricating-Oil Reclaimer on Semi-Diesel Engines

By Colin K. Lee

In a plant containing two 25-hp. semi-Diesel oil engines the cost of the lubricants was more than that of the fuel, amounting to from 120 to 130 gal. a month costing 60c. a gallon in barrel lots. It was impossible to cut down the feed, but there was a considerable drip out the crankcase, and this was collected and an attempt made to reclaim it. This oil was as black as printers' ink and contained not only finely divided carbon, but larger chunks of coke as well. We bought and tried a filter using Terry cloth, but found it a total failure, for the oil could not be clarified by straining through the cloth.

For a time the waste oil was placed in the fuel tanks and burned in the engines, but at last the suction screen of the engine fuel pumps clogged up with a sort of slime, like "mother-of-vinegar," of which the old lubricating oil seemed the cause. The fifty-gallon fuel tanks were found to contain a great deal of this scum and had to be cleaned out. As they could not be moved and contained virtually no openings save two holes for 1¼-in. pipe connections, this was a problem. At last water was turned into the tanks and allowed to run through until all the slime was floated out. Then a pipe was fitted into one of the holes and run to the bottom of the tank. When compressed air was turned into the other hole, the water came out in a flood and the job was done.

Thereafter the waste oil was thrown away, until at last we found and bought a reclaimer which filtered by coagulating the carbon particles under heat, and settling. This worked perfectly and saved its cost in six months. The reclaimed oil was used over and over with no apparent deterioration. New oil was used only for makeup. The compressed air for this reclaimer was taken from the compressor of the air-starter set, and the hot water was taken from the engine jackets. A piping arrangement with bypass was adopted, so that all or any part of the jacket-water from either engine could be sent through the reclaimer and bypassed around the cooling tower. With this the temperature could be kept as high as desired.

The comparative capacity of synchronous converters on a basis of average heating at unity power factors is that of a direct-current generator, where the direct-current generator capacity is taken as equal to 100; the same machine operated as a single-phase converter will be 85; operated as a three-phase converter, 134; as a quarter-phase converter, 164; as a six-phase converter, 196; and as a twelve-phase converter, 224.

Laurentide Electric Steam Generators Largest Yet Installed

Two Units, Each Consisting of Three Sections, Connected on a 6600-Volt Three-Phase Circuit—Each Generator Has a Normal Capacity of 25,000 Kw. and Has Absorbed 35,000 Kw. and Produced 50 Tons of Steam per Hour

By W. P. MUIR*

THE purpose of this article will not be to discuss the electric steam generator in general or its application, as these subjects have been thoroughly covered by F. T. Kaelin,[1] P. S. Gregory[2] and others, but to describe the largest and in some respects the most successful installation of the water-resistance or electrode type of electric steam generator. This type has been used in Europe for a number of years and was recently introduced into and further developed in Canada by the Shawinigan Water & Power Co., Shawinigan Falls, Quebec. This company has available during the high-water months of the year a considerable quantity of power over and above the ordinary requirements of its customers, and at all times of the year there is a certain amount of power that must be held as a reserve against possible demands of the system. This surplus or excess power which, under ordinary conditions, cannot be marketed, is now sold to the Laurentide Co., Ltd., in the form of steam for use in its paper and pulp mills, at a cost slightly less than that of producing it with coal. The steam is sold under a contract that permits the power company to reduce or discontinue the supply entirely upon one hour's notice. The power company is thus enabled to market the total amount of power that can be generated by the flow of the river, and the power wastage that previously took place during the high-water months of the year is now utilized for producing steam.

*Paper Mill Department, Dominion Engineering Works, Ltd., Montreal, Canada.

[1]Paper before Engineering Institute of Canada, Montreal, Jan. 9, 1922.

[2]Paper before American Electro-Chemical Society, Montreal, Sept. 23, 1922.

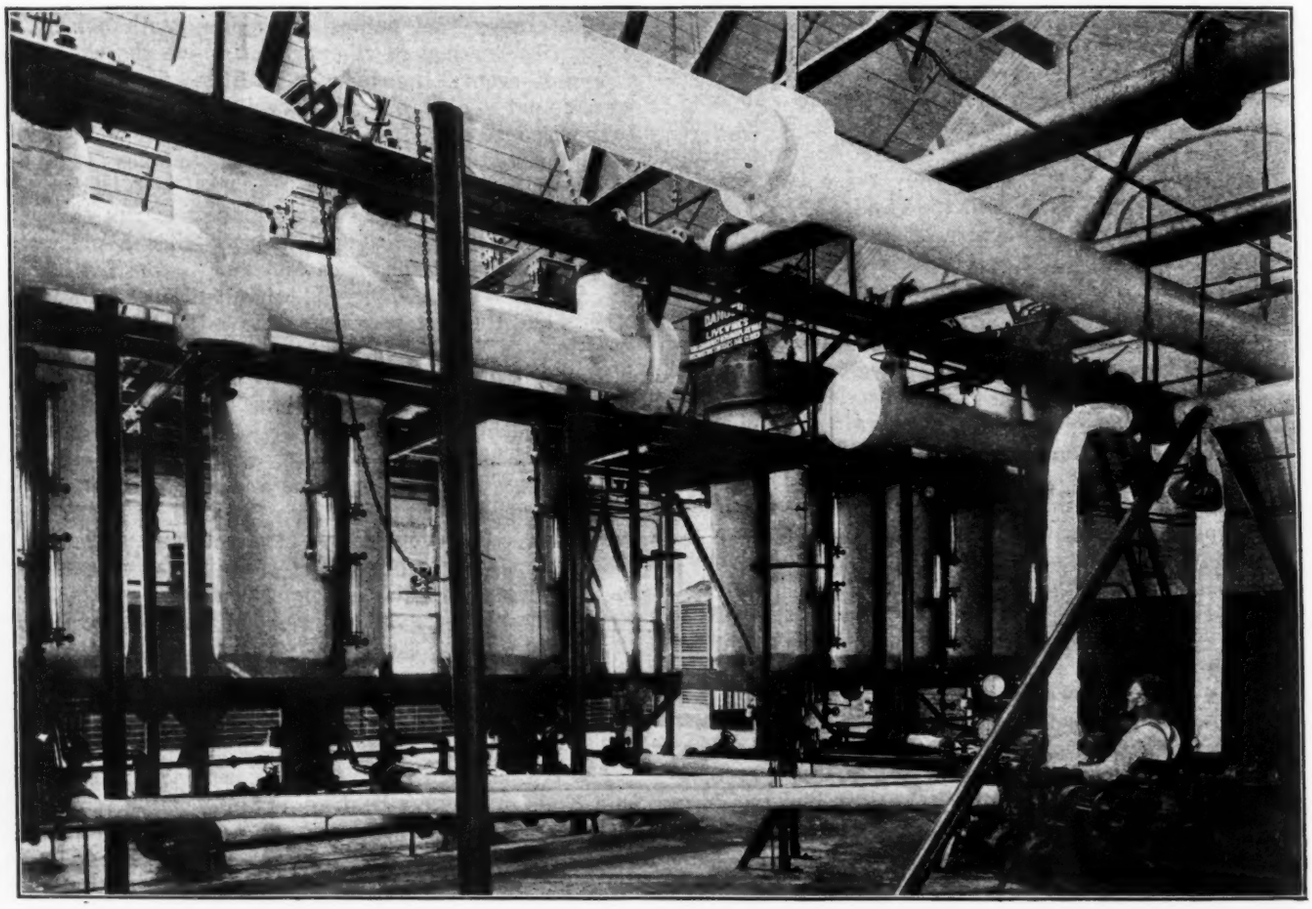


FIG. 1—CONTROL FOR THE TWO BOILERS IS CENTRALIZED SO THAT ONE ATTENDANT ONLY IS REQUIRED

Each boiler consists of three single-phase units. Each group of three units is connected to a common header on the steam end without intervening valves, and the header is connected to the main steam line. On the electrical end each three units are connected star. The neutral connection is shown in Fig. 4. Power input is regulated by controlling the water in the boiler.

With this end in view the Shawinigan Co. ordered from the Dominion Engineering Works., Ltd., Montreal, two electric steam generators of 25,000 kw. capacity each, which have been built and installed at the plant of the Laurentide Co., Ltd. In designing these generators, the manufacturers were guided by the general principles of design as developed by F. T. Kaelin, of the Shawinigan Co., and also by the experience gained in the construction and operation of a smaller unit of 15,000-kw. capacity of the same type and voltage at the paper mill of the Belgian Industrial Co. at Shawinigan Falls. This unit, the first of its type, was built by the Shawinigan Co. about nine months previously. However, it was decided to depart in some details from the original design of the Belgo generator in building these larger units. The contract for the construction was placed Feb. 3, 1922, and the first unit was erected and started on April 21, 1922, and the second three weeks later. It might be mentioned that each of these units has an equivalent evaporation of over 86,000 lb. per hour from and at 212 deg. F. They operate at 6,600 volts, and each consists of three single-phase tanks connected together in the steam connection, the three tanks being run as one unit and not as three generators. Fig. 2 shows a section through one of the tanks. The electrodes are steel cylinders provided with holes for free water circulation; the inner shells, or neutrals, protect the pressure vessel from any destructive effects of the large current passing from the electrode to the neutrals through the water and also preclude the possibility of an arc should it be established from endangering the safety of the shell. The electrode only is perforated, and not the inner shell, and has one-inch holes drilled to a number that reduces its outside cylindrical area about 5 per cent.

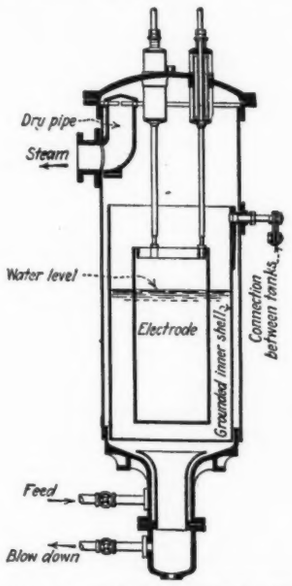


FIG. 2—SECTION THROUCH ONE TANK

A large covered dry pipe is placed inside each tank at the outlet nozzle. This dry pipe is constructed with a 1½-in. slot all around its periphery at the top with the exception of four strips left solid to support the cover, it being cast in one piece. The three tanks of each unit are connected together on the steam side through 8-in. outlet nozzles to a common steam header, 15 in. in diameter, on which are mounted the safety valves and the steam stop valves. There are no valves between this header and the tanks, so that it may be considered as a steam drum interconnecting the three sections of the unit. The water end of each tank is independent of the other two, as are the controls. There are six 4½-in. safety valves on each header and an automatic non-return valve between each steam header and main steam line. All nozzles on the header are welded, one 8-in. being provided for each tank, one 8-in. between the header and main steam line and a 6-in. for each pair of safety valves.

The three tanks for each unit are carried on a structural-steel frame, as shown in Fig. 4, and are well heat-insulated. The controls from the two units or six tanks are centralized at one location, where there are also three ammeters, one for each phase, and two pressures gages for steam and feed water for each unit (see Figs. 1 and 3). By centralizing the controls it is possible for one man to operate the whole installation without moving from his seat. A sudden demand for steam such as occurs when a digester is started can be easily met. The operator, seeing a slight drop in steam pressure, immediately builds up the load by raising the water level, and the generator responds with the required amount of steam in a matter of seconds. Even with the fluctuating requirements of a paper mill it is possible to meet all demands without any assistance from stand-by boilers and to maintain the steam pressure constant within 10 lb. of 125 lb. gage. On starting up, full steam pressure can be raised in from 5 to 10 min., but this is not unusual in electric steam generators.

Supplying Water to Boilers

The feed water is introduced between the inner surface of the bottom head and a funnel-shaped casting (Fig. 2) and is thus deflected up the sides of the tank, or in the direction of circulation, which is upward between the electrode and the inner shell, or neutral cylinder, and downward inside the electrode, instead of the

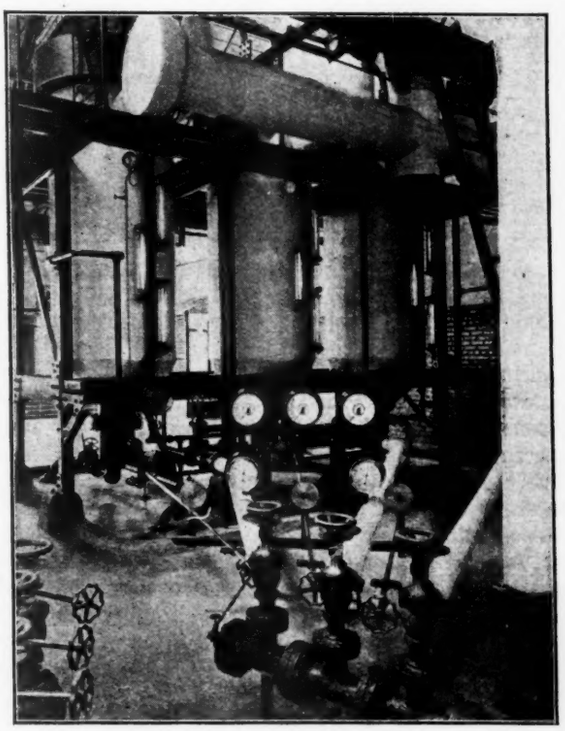


FIG. 3—VALVES AND METERS SHOWN IN FOREGROUND FOR CONTROLLING ONE BOILER CONSISTING OF THREE TANKS

arrangement of the Belgo generator, with the feed introduced in a central pipe directly up against the natural circulation. The dry pipes are also made with covered tops instead of open pipes as in the Belgo generator. These improvements and the improved circulation result in a reduction of the moisture content of the steam from over 3 per cent, as in the Belgo boiler, to less than 1 per cent for the Laurentide.

These features are the main points of difference between the earlier unit and the present design. The tanks are nearly the same size, 40 in. and 42 in. in diameter respectively, and the quality of the steam in the Laurentide generators has never been lower than 1 per cent moisture even when running at about 40 per cent overload, or 35,000 kw. in one unit. As a matter of fact, this overload capacity is not the limit of operation, but it is the highest load the power lines to the generators will stand.

It will be noted that there are three leads to each electrode through the top head, which is clearly shown at the top of the right-hand section, Fig. 4. These are

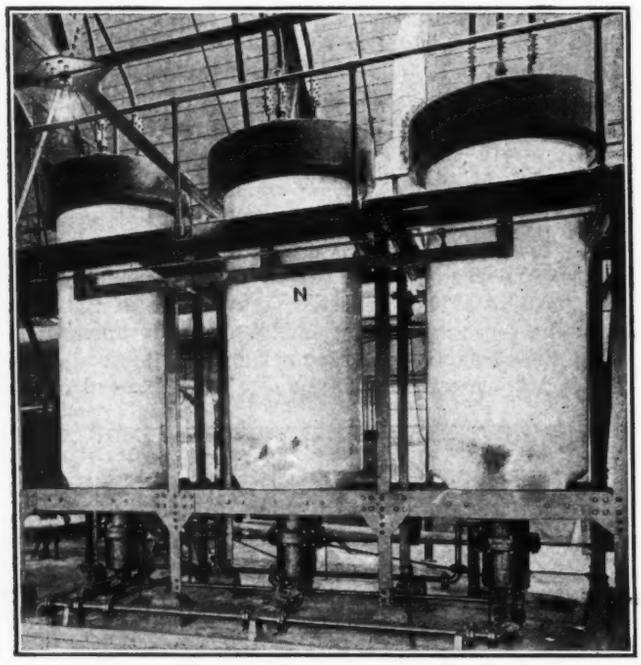


FIG. 4—NEUTRAL CONNECTION IS SHOWN AT *N*

all on the same phase, and the reason for using three is for mechanical stiffness to prevent the electrode from swinging. The leads are taken through heavy porcelain insulators which are of special construction for steam tightness. There is a certain wear and tear on the inner insulator, since even at the height they are located above the water, owing to the extremely violent ebullition, they are kept wet by the boiling water and scale is deposited on their surface. The scale forms a shunt path for the current, and it becomes advisable to examine these insulators from time to time and replace them when the deposit of scale would warrant. Considerable improvement is expected from making these insulators of quartz, and this possibility is being investigated.

Cost of Maintenance Small

The only other wear and tear on the unit is the destruction of the electrodes due to the high current emission. The electrodes start to burn off at their lower ends, possibly at the rate of six inches a year, so that their renewal once a year is necessary to maintain the unit in good condition. The maintenance expense for material amounts to about one per cent of their total cost per year. This maintenance cost has been found to apply to this extent only to steam generators for high voltage, that for lower voltages being proportionately reduced.

In conclusion a few facts about the operation of these units may be in order. They operate at about 96 per cent thermal efficiency. They are capable of generating together approximately 75 tons of steam per hour, with 50,000 kw. at their rated capacity. They have been run as high as 35,000 kw. each. At this load they will produce about 100 tons of steam per hour. They have supplied practically the whole steam demand of a large paper mill since their installation, and it is estimated that they will save in one year's operation about 50,000 tons of coal, or the equivalent of $500,000 at $10 per ton. The proportionate saving in labor is even more. One man on each shift can easily handle the whole installation, whereas it took 37 men to obtain the same capacity in 14 coal-fired boilers. Their total cost was not in excess of $150,000, so that allowing 20 per cent of this for interest, depreciation, repairs and maintenance, which is undoubtedly high, the direct operating saving will be in the neighborhood of $520,000 annually, assuming $50,000 saving in labor. This saving would be in the nature of increased revenue to the producer of the power without additional expense, considering that the power used could not be sold as such. These figures take no account of the interest, depreciation and maintenance changes on the coal-fired boilers, which must be maintained ready for operation should the power for the electric steam generator be cut off.

Magnetic Recovery of Fuel from Ashes

That magnetism, which has long been used for ore separation in the metallurgical industries, is now being successfully employed to recover unburned fuel from ashes, is stated in a recent issue of *Engineering* (London). The apparatus, devised by Messrs. Fried Krupp in Germany, depends for its operation upon the fact that practically all coal contains iron in the form of pyrites. Although the pyrites have no magnetic properties, they are converted into magnetic oxides of iron when the coal is burned. As the whole of the iron passes away with the clinker, the metal exists there in a much more concentrated form than in the original coal.

The actual separation is accomplished by passing the furnace refuse over a rotating magnetic drum, the ashes being delivered to the drum by a bucket elevator and a vibrating screen. Each size is passed separately on the surface of the drum. The clinkers, on account of the iron contained, are held magnetically to the surface for a portion of the revolution and then drop off into small wagons or other receptacles as the current exciting the portion of the drum that holds them is automatically broken. Particles of good coal and coke, containing no magnetic oxides, do not adhere to the drum, but leave it directly after contact, falling vertically into special hoppers. The magnetic action is sufficient to cause lumps of clinker up to 3-in. mesh to adhere to the drum, so that all lumps smaller than this are eliminated from the fuel.

These machines, of which approximately ninety are now in operation in Europe and elsewhere, are built in capacities ranging from one-half ton to two tons of ash per hour. The fuel recovered can either be burned under boilers by means of forced draft, or it can be briquetted, both methods being in use.

No figures were given to show what percentage of the combustible in the ash can be recovered by this apparatus.

A Performance Scale for Ammonia Refrigerating Plants

By T. M. GUNN

SUPPOSE you were told that a refrigerating plant obtained a ton of refrigeration for two horsepower-hours while a second plant required three horsepower-hours. Could you determine which plant was actually working most efficiently? T. M. Gunn discusses plant performance and gives a scale by which operating results may be compared with the ideal ones for any pressure range. By its use the engineer can find how well his plant is doing without any complex mathematics.

FOR nearly every product there is a standard by which it can be measured. Some materials are measured by a weight scale of pounds or tons and others by a volume scale such as the bushel, gallon or cubic foot. Linear scales, reading feet and inches or meters and fractions, are common. Temperatures are measured in degrees, by either the Fahrenheit or the Centigrade scale. Heat energy is commonly measured in British thermal units. Power output is measured in horsepower or kilowatts. The performance of a steam plant is variously measured in steam consumption or in pounds of coal per horsepower, etc. More technical investigation of the steam plant leads to figures showing its thermal efficiency or over-all efficiency.

Refrigerating plants develop their product in the form of cooling effect, or heat removal. For this product the unit of measurement is the commercial ton of refrigeration. A machine developing one commercial ton of refrigeration absorbs, per 24 hours, as much heat as one ton (2,000 lb.) of ice would absorb while melting. One pound of ice must absorb 144 B.t.u. to melt, and therefore a commercial ton of refrigeration represents the absorption per 24 hours of 2,000 × 144 B.t.u., or 288,000 B.t.u. This is a rate of heat absorption and can equally well be expressed as 12,000 B.t.u. per hour or 200 B.t.u. per minute.

Effect of Temperature

The product of the refrigerating plant is not fully described or measured in terms of the commercial ton refrigeration, because that does not take into account the temperature at which heat is removed. Ice melts at 32 deg. F., and removes heat at that temperature. Refrigerating plants may remove heat at any temperature, from, say, 40 deg. F. down to 40 deg. or more below zero. Evidently, a ton of refrigeration at minus forty degrees requires the expenditure of more power than a ton at plus forty.

To make this clear, consider the refrigerating plant as a heat pump. The work of a pump is that of lifting a weight of water to a height. A pump that delivers a ton of water per minute against a head of twenty feet is doing only one-fifth as much work as one pumping water at an equal rate against a head of one hundred feet. It would be unfair to compare the pump performance in these two cases by the horsepower per ton of water pumped. In other words, the output of the pump is the product of weight lifted multiplied by the head.

In the refrigerating plant the effect in commercial tons of refrigeration represents the rate at which heat is moved and corresponds to the weight of water lifted per minute by the pump, while the difference between the temperature of the cooling coils and that of the condenser (a difference sometimes called the heat-head) corresponds to the head against which water is pumped.

This comparison makes it clear that a refrigerating plant can accomplish more tons of refrigeration when the temperature difference or heat head is small than when it is large, which is a fact of importance. It should be remembered that the output of the refrigerating plant is not alone tons of refrigeration (or B.t.u. removed), but also heat head, and the real output is the product, tons of refrigeration × heat head, which might be called "ton-degrees."

Each refrigerant (ammonia, carbon dioxide, etc.) has its own physical characteristics which limit the effectiveness with which it can be used. This effectiveness also varies with the temperatures, introducing into the refrigerating plant a variable factor that does not exist in the pump used for comparison. What, then, can be done by a refrigerating plant under ideal conditions? Can we not adopt a cycle of performance, calculate from the physical properties of the refrigerant what the ideal performance is and use this as a scale of comparison between one refrigerating-plant performance and another? The writer has done this for ammonia, and has so arranged the results in chart form that it is very easy to ascertain what the theoretical or ideal performance is under stated conditions of temperature, pressure, etc.

The Standard Refrigerating Cycle

Of theoretical cycles there could be any number; so it is necessary to define the assumptions on which this cycle is based: (1) Single-stage, adiabatic compression, which is very near to what takes place in the ordinary compressor; (2) condensation at a uniform pressure throughout the condenser, this being practically true in all condensers; (3) liquid ammonia not precooled, but remaining at its condensing temperature until it reaches the expansion valve (sometimes in practice it becomes warmer, which is a loss, and sometimes it is precooled, which may be a gain); (4) evaporation taking place at a uniform pressure, practically true in nearly all cases; (5) suction gas entering compressor dry and saturated, that is, not carrying liquid nor superheated, and this is close to the condition generally considered best for practical operation, namely, with as few degrees of superheat as can be maintained with certainty; (6) friction in pipes and valves and radiation of heat to or from the compressor and connecting pipes of the system, assumed to be zero.

In general, the assumed conditions for this cycle, as outlined in the preceding paragraph, are not far from those existing in many refrigerating plants, and an advantage of these assumptions is that they can be defined and are subject to calculation. This cycle is

therefore a convenient standard of comparison or scale by which to compare refrigerating-plant performance, and will be spoken of as a performance scale.

This performance scale for ammonia plants serves the same purpose as does the Rankine cycle used in analyzing steam-plant performance. The scale is much closer to actual refrigerating-plant performance than the Rankine cycle is to the performance of the piston engine and nearly as close as the Rankine cycle is to actual steam-turbine results.

The specific information needed for comparing actual and ideal or scale performance has to do with the following: (1) The refrigerating effect, in terms of size and speed of the compressor; and (2) the horsepower required per ton of refrigeration. It is also useful at times to know (3) the quantity of heat passing out through the condenser into the cooling water and (4) the number of pounds of ammonia expanded per ton of refrigeration. All these quantities can easily be calculated for the performance scale by the use of the ammonia heat diagram that was illustrated and explained in *Power*, Sept. 26, 1922. The calculations are simple, but take time, consequently the writer has made computations for over one hundred operating conditions within a selected range, and the results have been combined into chart form in Figs. 1 and 2. By these charts the performance of the theoretical or idealized refrigerating plant, which we call the performance scale, can be found without calculation. Their use will be explained after a few expressions have been defined.

The commercial ton of refrigeration has already been defined as the rate of heat removal, the unit being 200

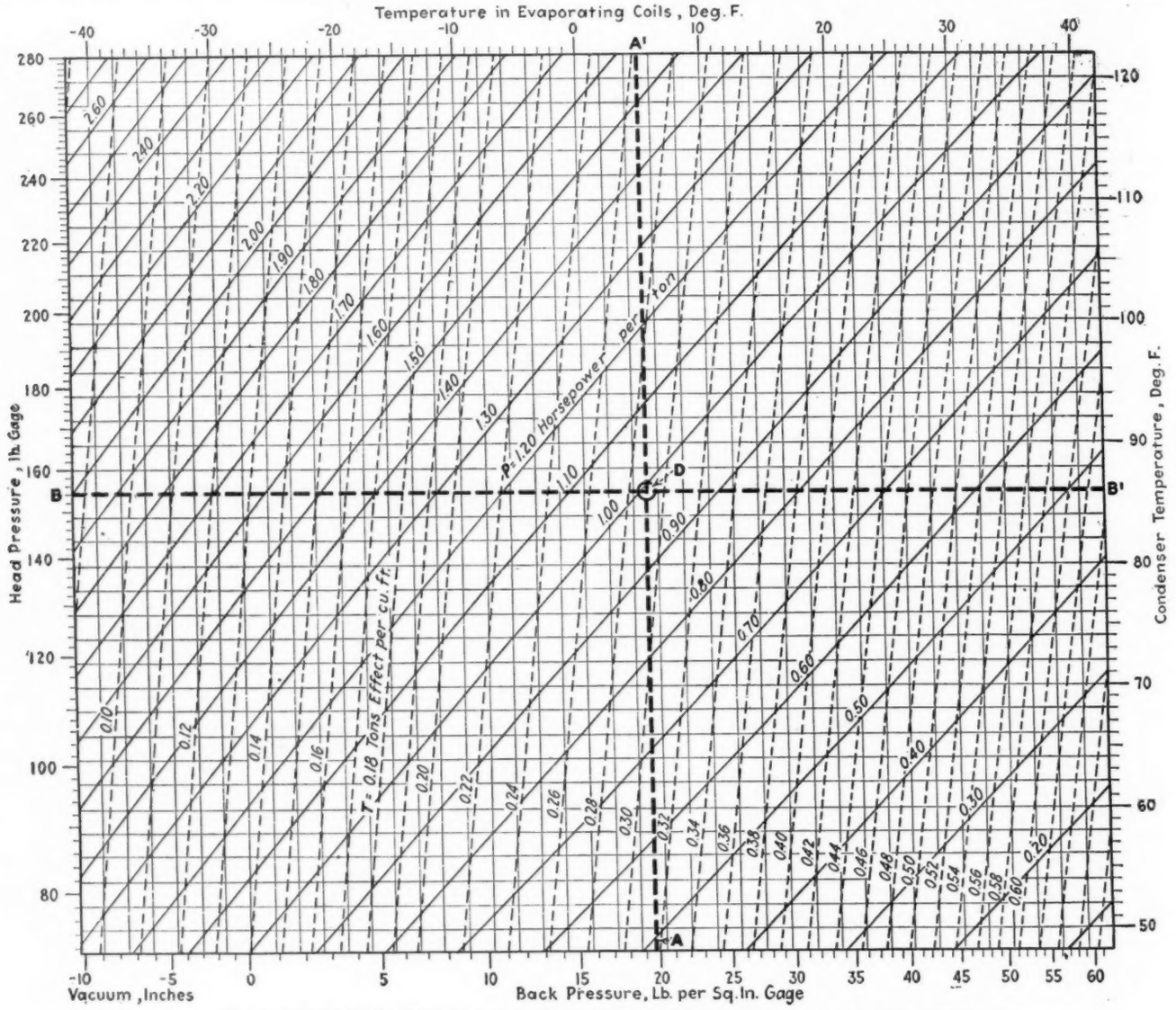


FIG. 1—PERFORMANCE CHART SHOWING HORSEPOWER AND COOLING EFFECT

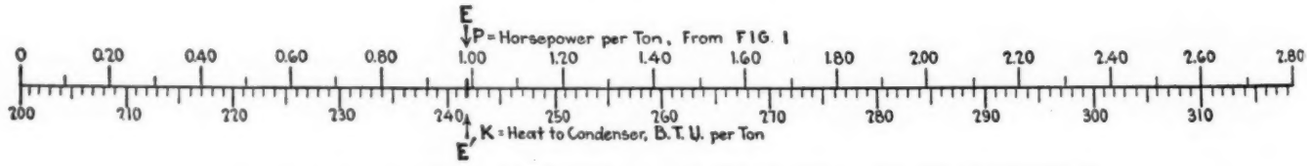


FIG. 2—RELATION OF HORSEPOWER TO THE HEAT GOING TO THE CONDENSER

B.t.u. removed per minute. When we speak of refrigerating effect in tons, it should be understood that it is measured in this way.

One of the principal factors that determine how much refrigerating effect can be attained is the volume of suction gas that the machine can compress per minute. This will be spoken of as suction capacity, in cubic feet per minute. This can be calculated as follows: Ascertain the area of the piston in square feet, the stroke in feet, the number of compression strokes per minute (remembering to multiply by two if it is a double-acting compressor); find the product of these three numbers and multiply that product by a number less than one, called the *volumetric efficiency*, now to be explained.

The volumetric efficiency is less than one because part of the cylinder volume is occupied by re-expanded ammonia that was not expelled by the piston on its preceding stroke; because suction gas begins to expand owing to heat absorption from the cylinder walls before the suction stroke is completed; and also because valves cannot be made to operate entirely without resistance and leakage and may fail to open and close exactly as they should. Volumetric efficiency varies with the type and make of compressor, and in each compressor it varies with the ratio of head and back pressures, and of course varies when the valves become leaky or sluggish.

Any method of determining volumetric efficiency other than actual test is open to criticism. The following table gives values representing averages from a number of tests. To use this table, divide the head pressure (absolute) by the back pressure (absolute); this gives the ratio of compression. Find the number in column 1 nearest to this, and the probable volumetric efficiency will be found in column 2.

Ratio of Head Pressure, Abs. / Back Pressure, Abs.	Compression Volumetric Efficiency Approximate Average
4.0	0.86
4.5	0.85
5.0	0.84
5.5	0.83
6.0	0.82
6.5	0.81
7.0	0.80
7.5	0.79
8.0	0.78
8.5	0.77
9.0	0.76
9.5	0.75
10.0	0.74
10.5	0.73
11.0	0.72

Example: To find the suction capacity of a single-acting compressor with a cylinder diameter of 10 in. and a stroke of 14 in., operating at 150 r.p.m. with a back pressure of 19.5 lb. and a head pressure of 154 lb. gage.

The area of a 10-in. circle is 0.542 sq.ft.

The stroke, 14 in., is equal to 1.167 ft.

The number of compression strokes per minute is 150.

To find the volumetric efficiency, first get the ratio of compression: $\frac{154 + 14.7}{19.5 + 14.7} = \frac{168.7}{34.2} = 4.93$ compressions. In the table the nearest ratio to this is 5.0, for which the probable volumetric efficiency is 0.84. Now, multiply together to get the suction capacity of the compressor:

$$\begin{matrix}\{\text{Piston area, sq. ft.}\} & \times & \{\text{Stroke, ft.}\} & \times & \{\text{Strokes, per minute}\} & \times \\ \text{or } 0.542 & \times & 1.167 & \times & 150 & \times \end{matrix}$$

$$\{\text{Volumetric efficiency}\} = \{\text{Suction capacity, cu.ft. per min.}\}$$

$$0.84 = 79.5 \text{ cu.ft.}$$

per minute suction capacity of compressor.

The next step is to learn how much refrigerating effect could be obtained in the theoretical plant (performance scale) by the use of a compressor having this known suction capacity (79.5 cu.ft. per min.). For this purpose refer to the chart, Fig. 1.

On the bottom scale find the point *A* for the back pressure of 19.5 lb. gage. From this point draw a vertical line to the top of the diagram to the point *A'*. There the temperature in the evaporating coils can be read as 5 deg. F.

On the scale at the left find the point for the head pressure of 154 lb. gage at the point *B*. Trace a line to the right-hand scale, where the temperature of condensation can be read, see point *B'*, reading 86 deg. F.

The vertical and horizontal lines just drawn intersect in the point *D*. Giving attention to the nearly vertical broken lines on the diagram marked "*T* = Tons Effect per cu.ft.," the point *D* is seen to lie halfway between the lines marked 0.28 and 0.30 and should be read 0.29. The full meaning of this is that for every cubic foot per minute of dry saturated ammonia vapor entering the compressor suction, a refrigerating effect would be obtained at the rate of 0.29 commercial ton. For the compressor used in the preceding example, it was found that its suction capacity was 79.5 cu.ft. per minute, and therefore the refrigerating effect of this compressor by the performance scale is $79.5 \times 0.29 = 23.05$ tons refrigeration.

This refrigeration, based on theoretical or performance scale conditions, should be compared with the actual refrigeration obtained in the plant.

Horsepower Requirements

Next, let us investigate the horsepower. Observing the diagonal full lines on the same chart, Fig. 1, the point *D* is observed to lie between the lines for *P* marked 0.90 and 1.00, but much nearer the latter, so that it should be read: $P = 0.99$ horsepower per commercial ton refrigeration. The last calculation showed the refrigerating effect to be 23.05 tons, and therefore the horsepower of the compressor is $23.05 \times 0.99 = 22.82$ hp. This is the scale horsepower by which to measure actual performance; it should be compared with the indicated horsepower of the ammonia cylinders.

All the heat absorbed by the cooling coils must be delivered to something else, as must also the heat that results from the work of the compressor. The condenser is provided for the purpose of delivering this heat to the cooling water. The amount of this heat going to the condenser, or more strictly, the amount of heat discharged by the plant per ton of refrigeration bears a simple relation to the horsepower of compression per ton, which relation was used in making the chart for the heat to the condenser, Fig. 2.

For a horsepower per ton of 0.99, as found by Fig. 1, find the point *E* on the upper scale of Fig. 2. At the corresponding point *E'* on the lower scale, read the value of *K*, 242 B.t.u. per ton. By multiplying this number by the refrigerating effect, 23.05 tons, the total heat going to the condenser and discharged by it is $242 \times 23.05 = 5{,}578$ B.t.u. per minute.

With a closed condenser, such as the double-pipe type, it is easy to calculate the heat delivered to the cooling water by measuring the quantity of water per minute and its rise in temperature. This actual heat discharged by the condenser may be compared to the performance scale figure just given, thus affording another means of checking the performance.

By examining the chart Fig. 1, much can be learned regarding plant operation and economy. It shows that power is decreased per ton by increasing back pressure and decreasing head pressure. Secondly, it shows that the higher the back pressure, the greater is the capacity of a machine. These are the fundamental laws for successful refrigerating-plant operation. The most serious thought and work of the engineer should go to the accomplishment of these ends.

The performance scale or theoretical cycle, intended as a basis of comparison for the performance of actual plants, can be used to show the degree of perfection of plant performance in regard to the plant capacity and the power used. One plant, operating poorly, may develop only 25 per cent of the scale capacity and may use five times the scale horsepower. Probably such a plant needs a new engineer, but the engineer still has a chance if he is the one who first discovers this deplorable state of affairs. Another plant may develop 95 per cent of scale capacity, using 1.25 times the scale horsepower. This would be unusually good performance for the ordinary plant.

Some plants are equipped to take advantage of the possibilities of precooling liquid ammonia, compounding the compressor, and other methods of economizing. When such plants, operating under the best possible conditions, are compared with the performance scale, they may show better actual than scale performance.

Determining Compression Pressures for Solid-Injection Oil Engines

By H. F. SHEPHERD

QUITE frequently one hears, in discussion regarding oil-engine specifications, some such remark as, "Now if I were building an oil engine, I would prefer a compression of such and such a figure, a scavenge pressure of so much less," and so on, enumerating the various basic characteristics of the speaker's ideal design. Some men are imbued with the Diesel ideal, forgetting or ignorant of the fact that constant pressure combustion is not consistent with the best working efficiency of the solid-injection engine. Others prefer low compression for the sake of the reduced working pressure when operating with a moderate load.

It is altogether possible to design around a given compression ideal, but there are some inseparable factors to be considered in conjunction with that characteristic. These factors intrude themselves and are the result of inherent properties of various types. We have control over them in some degree, but it is by no means absolute.

In 1916 the writer designed the combustion head shown in the sketch. Its principle is the control of the hot surface temperature by the vaporization of a liquid in contact with that surface. The liquid chosen, mercury, has a boiling point equal to the required temperature. The liquid supply is made permanent by condensing its vapors against the jacketed cover and returning the condensate by gravity to the well, the metal bottom of which is the hot surface. This device is still in use and works well in its proper field, but aside from any question of its commercial value it has been of great use as a laboratory apparatus.

The conduction of heat along the vertical wall of the "hot pot" is exceedingly small by design, and the heat-flow along this wall can be calculated with fair accuracy. The major portion of the heat dissipated from the hot surface as excess is transmitted to the jacketed cover by the rising vapors. The quantity of heat dissipated may be reckoned by measuring the water flow through the cover jacket and the rise of water temperature.

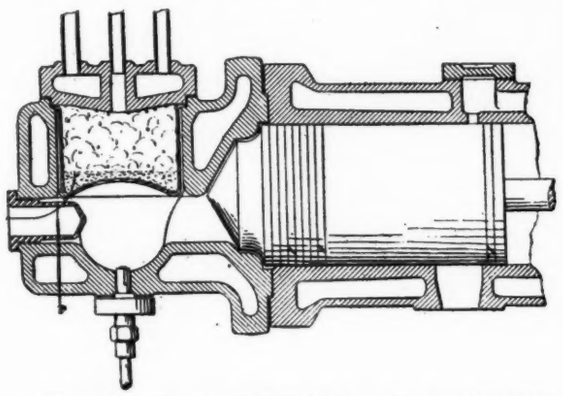
By varying the pressure of air within the pot and above the liquid, the boiling point of the liquid may be raised and the temperature control altered at will and plotted against fuel economy, exhaust temperature, etc., or weighed against any operating characteristic. It has long been known that fuel cracking and afterburning are the result of too much heat in the semi-Diesel engine, either at the hot surface or in the air charge during the time of injection. The device was used to ascertain finite values for the hot surface temperature and its relation to operation. It showed the best point for the hot surface temperature to be very close to 850 deg. Below 850 deg. F. and down to 680 deg. a rise of about 6 per cent in consumption was noticed with light free-boiling fuels and 12 per cent with heavy asphaltic fuels. Between 680 and 850 deg. the exhaust was all that could be expected from the type of engine. Operation was inclined to go bad rapidly above 850 deg. and especially as 950 deg. was approached. These temperatures were taken by the very accurate method of staking the elements of a thermocouple right into the metal of the hot-pot bottom, the wires being led out through the cover in a tube.

While it would be wrong to assume that these figures give the exact limits of the working compression end temperature when the hot surface is not in use, they at least lead to a fair assumption of proper values, although it must be borne in mind that most of the fuel is injected before the end of compression and the completion of compression must cause ignition. These figures also reveal the great mercy of Nature toward the fraternity of oil-engine designers. There is a range of almost 200 deg. F. between the minimum and maximum temperatures to which the fuels may be subjected without bad operation or serious change in economy.

As operation is possible well below the lower limit and as it goes bad at a temperature but little above the upper limit, it may be concluded that it is best to work below the optimum temperature of approximately 850 deg. at full load, for the reason that should a bad exhaust condition be encountered, an engine with a normal compression end temperature of 850 deg. would suffer greater than one working normally at about 680 deg. The latter engine would probably work within limits under any condition.

It is owing to the nearly fixed upper limit of tem-

perature to which an oil may be subjected for the proper vaporization which should precede ignition that two-stroke-cycle engines are unable to work with crankcase compression, or the one-to-one scavenging system, at the high compressions employed in the four-stroke-cycle engines. When high compression is attempted in the primitive two-stroke-cycle hot-bulb engine, the compression end temperature runs far too high owing to the high charge temperature, which in turn is due to partial scavenging. Conversely, if low compression is desired for hand starting, as in oil-well pumping engines, the more primitive two-stroke-cycle systems lend themselves readily to the need. They will attain the lower working temperature limit with far less compression ratio, and in compensation for the reduced m.e.p. brought about by the reduced free air charge, they will deliver two explosions to one of the four-stroke-cycle type. Obviously, the four-stroke-cycle



ENGINE USED TO DETERMINE ADVANTAGEOUS TEMPERATURES

engine can and will operate on low compression pressures if it is provided with a valve setting such as to cause re-aspiration of exhaust gases, but the commercial handicap of a reduced m.e.p. puts such procedure out of the question.

Admitting the usefulness of the two-stroke-cycle one-to-one scavenging system in some situations, the type has one serious drawback. If we fix the quantity of scavenging air so that, with a low compression in use, the engine will operate well at friction or light load—that is, at the lower working compression end-temperature limit—with a full load and far hotter residuals and walls the compression end-temperature is liable to exceed the upper limit.

All engines, no matter how perfectly cooled and scavenged, show some increase of charge temperature due to hotter residual gases and hotter walls as the load increases. It is wiser to keep on the low side of the compression limit than on the high side, for overload is always to be considered, and the engine with a more moderate compression will most certainly be the last to show distress from heat.

This brings us to certain propositions:

1. The two-cycle-stroke solid-injection engine must have a compression suited to the degree of scavenging made possible by its design and development.

2. Conversely, the scavenging system of a two-stroke-cycle engine must be suited to the desired compression value.

3. Propositions 1 and 2 apply with somewhat less force to the valve dimensions, valve settings and the exhaust system of the four-stroke-cycle engine.

4. The maximum degree of compression practicable for a solid-injection engine depends in a measure on the efficiency of the cooling of the valves and piston.

If there were no charge heating from wall-action or no residuals retained, the engine would work equally at all loads, and assuming compression end-temperature limits of 680 to 850 deg. F., with a compression exponent of 1.35 and an initial temperature of 60 deg. F. we might expect good working within compression pressure ratio limits of 20.71 to 35.42. At 14 lb. absolute as the initial pressure, these figures would place the minimum compression limit at 275 and the maximum at 482 lb. gage.

We know that four-stroke-cycle engines working at 225 lb. compression require compensating devices to permit starting and proper working at friction load. Wall-action and hotter residual gases contribute to first-class operation at full load. Experience with four-stroke-cycle engines working with less than 225 lb. compression has discouraged many designers.

At 250 lb. compression a properly designed four-stroke-cycle engine will operate at friction load and with no compensating device or hot surface, but it will show some white vapor in the exhaust, indicating lack of heat. At full load about one hour of operation will be required before the engine comes to normal working economy, showing that some dependence is placed on heat derived from wall-action. This effect, of course, is exerted mostly during the introduction of the charge.

At 300 lb. compression the same engine, if of fair size, should idle with a clear exhaust, and experience has proved that a well-cooled and well-scavenged solid-injection engine will operate with 400 lb. compression at high economy. Some engines have been worked successfully at 450 lb. compression, but there is no record of improvement beyond that figure, and certain engines have actually shown a decrease in economy when compression was raised above 400 lb. It is thus evident that our ideal values, when modified by the actual best charge temperature attainable in practice, are very nearly correct.

The writer's experiments and those of others have placed economies for modern four-stroke-cycle engines approximately as follows: At 225 lb. compression, 0.46 lb.; at 275 lb. compression, 0.44 lb.; at 400 lb. compression, 0.4 lb.; at 460 lb. compression, 0.46 to 0.49 lb. per hp.-hr. These figures may have been bettered occasionally, but the values given are those that one might expect to equal in testing every unit of a series.

As an offset to what has been said regarding idling at 300 lb. compression, it may be urged with some truth that certain engines employing as much as 400 lb. compression do not operate well below quarter-load. These engines in every instance spray the fuel against the piston and are in a category of their own. They follow in some degree the laws governing the operation of hot-surface engines.

It is impossible to set any limits for two-stroke-cycle semi-Diesel engine compression. Such engines may work successfully from 150 lb. compression up to a point near to the limit for four-stroke-cycle engines, so much depending on the system of scavenging provided.

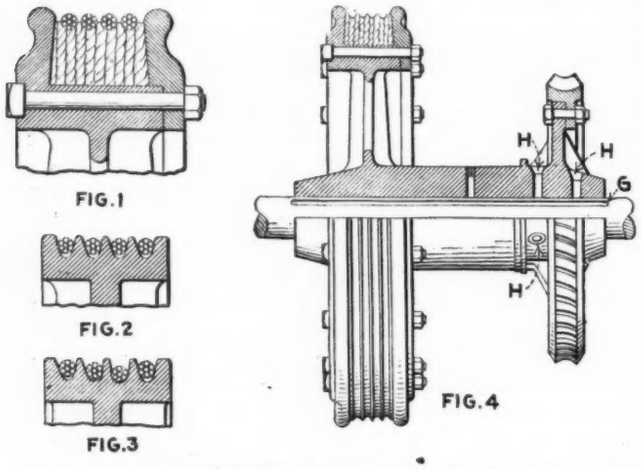
Much satisfaction has been derived from the application of Underfeed Type E stokers to two small Dutch steamers equipped with single Babcock & Wilcox marine boilers, according to *The Engineer* (London).

Hemp-Fiber-Packed Sheave Used on Traction Elevator Machine

DESCRIBES a new type of single-wrap traction elevator machine on which the traction-sheave face is made of short pieces of hemp fiber set radially and known as a fiber-packed sheave.

DURING the last eight or ten years there has been a very marked improvement in electric-elevator designs. Drum-type machines which were in such general use are being rapidly superseded by the traction type. For a considerable period the tendency was toward the double-wrap traction machine, on which the cable passed from the car over a driving sheave and to an idler sheave, back over the driving sheave and to the counterweight. The tendency today is away from this type of machine to the single-wrap machine, where the cables pass from the car over the driving sheave to the counterweights. This type has advantage over the double-wrap type, in that the loads on the drive shaft of the single-wrap machine are only approximately 50 per cent of those for the double-wrap type, and in many installations no idler or deflecting sheave is required. Where the diameter of the driving sheave is less than half the width of the car, an idler sheave must be installed, but this is for deflecting purposes only and may be of much lighter construction than when used on the double-wrap machine. These two features allow the use of a machine of lighter construction, which results in a material reduction in cost of construction. Where the cables in a double-wrap machine bend three times around the sheaves, in the single-wrap machine they have but one bend. Theoretically, reducing the number of bends in the cables should increase their life, but there are factors that enter into the operation of the single-wrap machine that make this a questionable matter.

In the single-wrap machine the maximum contact arc between the cables and sheave cannot exceed 180 deg. and is less than this for equipments using a deflecting sheave. Where steel cables are used on a steel sheave sufficient traction cannot be obtained between the cables and sheave with a semicircular groove as used on the double-wrap machine, so that some sort of pinch groove has to be employed, a common type being a "V" groove. In modern single-wrap machines different types of grooves are used, but they all are shaped so that the cables cannot bottom in the grooves, which allows a pinching action between the sides of the grooves and cables, as indicated in Fig. 2. One of the difficulties with this arrangement has been to have all the cables travel at the same speed. To obtain this condition it is necessary that all the grooves and cables be alike. If one cable or groove wears more than another, a condition similar to Fig. 3 will exist on the sheave and cause the cables to travel at different speeds, therefore they will have to slip in the grooves to compensate for the difference. When a "V"-groove sheave has worn so that one or more cables be $\frac{1}{16}$ in. lower than any of the others, the creep will amount to about 10 in. for a 200-ft. lift. Obviously, under such conditions the wear on the cables will be severe.



FIGS. 1 TO 4—SECTIONS THROUGH SINGLE-WRAP TRACTION-ELEVATOR MACHINE SHEAVES

Figs. 1 and 4—Show construction of hemp-fiber packed sheave. Fig. 2—Section of "V" grooved sheave with all cables and grooves the same size. Fig. 3—Condition that can develop on a "V" grooved sheave when the cables or grooves wear unevenly.

How the Face of the Sheave Is Built Up

To increase the friction between the cables and traction sheave of single-wrap machines without the pinching action of the "V"-groove type, and at the same time reduce the wear on the cables, a hemp-fiber-packed sheave has been adapted to a new elevator machine built by the American Machine & Foundry Co. As shown in Figs. 1 and 4, the sheave's face is built up of short pieces of hemp fiber set radially and held between two flanges, and it is known as a fiber-packed sheave. The fiber is held under a pressure that makes it a solid mass. After the sheave has been assembled, it is put into a machine and the grooves, which are semicircular in shape, are rolled in. The idea is to get the conditions in a rope drive where a hemp rope is run on iron or steel sheaves. In the hemp-packed sheave the arrangement is reversed—an iron or steel rope runs on a hemp-fiber sheave.

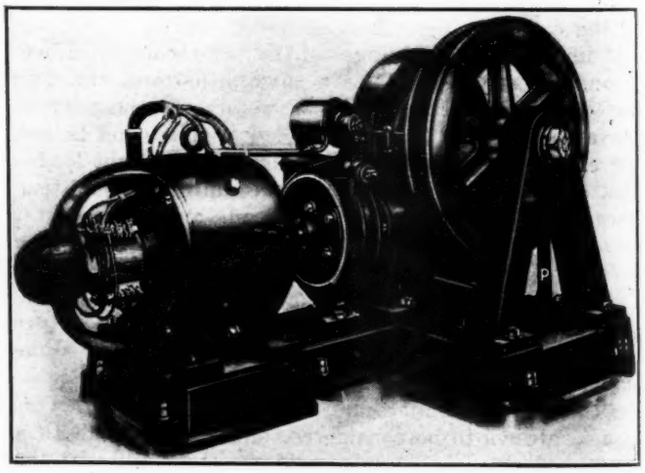


FIG. 5—TRACTION-ELEVATOR MACHINE WITH HEMP-FIBER PACKED SHEAVE

Where, with a steel sheave and ropes it is necessary to use six cables to obtain sufficient traction, with the hemp-packed sheave a lesser number of cables may be used on the same lift.

The elevator machine is of the worm-gear single-wrap traction type, Fig. 5. By referring to Figs. 4 and 6 it will be seen that the spider for the worm gear and the

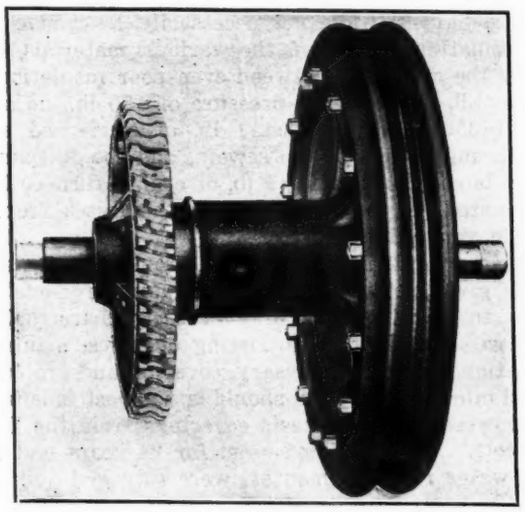


FIG. 6—GEAR AND SHEAVE SPIDERS CAST AS A UNIT

traction sheave are cast in one piece on a hollow shaft. This eliminates any possibility of the sheave's working loose. The gear is held to its spider with tight-fitting bolts in reamed holes. These bolts have castellated nuts,

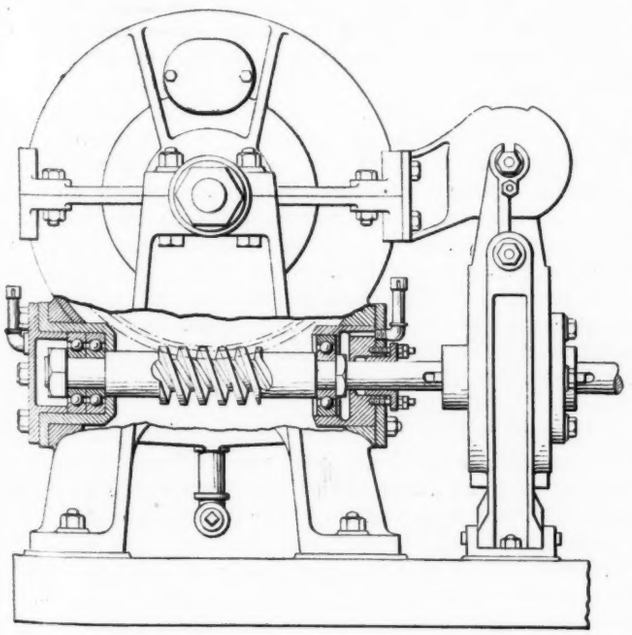


FIG. 7—DOUBLE BALL THRUST BEARING ON REAR END OF WORM SHAFT

which are prevented from working loose by cotter pins. The sheave shaft is held stationary in its bearings and acts as a bearing for the sheave and gear unit, which revolves on it. Since the shaft is held stationary, it acts as a stiffener for the bearing pedestals.

Lubrication to the sheave and gear shaft is supplied from the gear case through a number of holes bored in the gear-spider hub, as indicated at *H*, Fig. 4. A groove in the shaft distributes the oil the full length of the hub. The oil that runs out at the sheave end is returned to the gear case by a pipe connection shown at *P*, Fig. 5. A cast-iron bushing is used in the gear and sheave hub to provide the bearing surface on the steel shaft.

The gear is of cast bronze having a tensile strength of about 90,000 lb. per sq.in. and meshes into a 0.4-carbon steel worm. At the motor-end the worm shaft has a ball guide bearing lubricated from the gear case. A baffle is placed on the end of the worm hub to prevent dirt from the gear case getting into the ball race. Both front and back thrust are taken care of by a double ball bearing at the rear end of the worm shaft, as in Fig. 7. This places the thrust bearing where it is easy to get at should adjustments or renewals be necessary, and allows any expansion or contraction of the worm shaft, due to temperature changes, to be taken care of in the ball guide bearing. On the brake, Fig. 8, the shoe on the left-hand side of the brake wheel is connected to the right-hand core of the magnet and the right-hand shoe to the left-hand core, so that when the two cores are pulled together the brake shoes are lifted when hinged at the lower end. The necessary pressure between the brake shoes and the wheel is obtained by adjusting the tension springs *S*, which are mounted on a through-bolt. Clearance of the shoes from the wheel is controlled by adjusting the cores in the magnet. These cores are adjusted by lengthening or shortening the stem *M* until, when the cores are pulled together, the shoes will be just clear of the wheel. Bolts *B* are used to obtain equal clearance for each shoe.

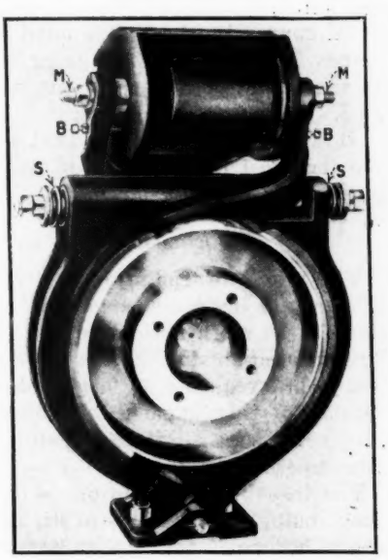


FIG. 8—BRAKE ASSEMBLY

A separate transformer or group of transformers for each rotary converter is preferable, as an entire unit can be cut out of operation independently and a more flexible and reliable system obtained; also the converters are less sensitive, the use of the single transformer or group or transformers affording some flexibility between the converters, regarding field excitation, etc. If several converters were operated from the same transformer group, the failure of any transformer would cripple the whole system. Moreover, the single transformer group would have to be large enough for all the converters under maximum-service conditions, while ordinarily they would be operated only at a fractional load and a corresponding low power factor. The voltage ratio of the transformers should be such as to give full-load secondary voltage corresponding to full-load converter voltage.

Cutting Fuel Costs

BY GEORGE F. SWETNAM

Years ago it was customary to leave heated surfaces uncovered. It was also customary to oil engines with a tallow pot, which sat on the cylinder and contained fish oil. Now engines are automatically lubricated with scientifically selected oils. New pressure systems, filters and separators are being devised daily.

But even now it is easy to find steam mains, some of which are hundreds of feet in length, without protection, and boilers with nothing better than a layer of soft brick and cement. Heat that should go to the engines or heating system is wasted on the way, and mechanical draft is employed because leaks in the boiler breechings and stacks waste the heat that should create the draft.

Of course the heat so wasted is lost, and whether it comes from heaters, fittings or steam pipes, the source is the same; it all comes out of the money spent for fuel.

However, it is probable that at least 90 per cent of the heat lost comes from steam pipes. Such pipes are much too frequently left bare.

TWOFOLD RESULTS OF RADIATION

The result of radiation is twofold, the one, loss in efficiency, being more serious, while the other, condensation, is the more noticeable and the more easily gaged. Superheated steam contains more energy than saturated steam, but requires no larger pipe or higher pressure; because of this, superheaters have come into use. But why heat it at all if the heat is to be wasted to the atmosphere?

The loss by condensation is quite large. One company, using a steam main slightly over an eighth of a mile in length, found that it wasted almost forty carloads of coal a year. Properly applied, $1,500 worth of insulation saved more than four-fifths of this fuel. Another company installed a steam main 2,500-ft. in length, but found that nearly all the steam was condensed before reaching the engines. When well insulated, there was a drop of only five pounds in pressure over the whole line, while another line, also insulated, showed a drop of only eight pounds, although the line was twice as long as the other.

GOOD RESULTS SHOWN IN INSULATION OF ELECTRIC FURNACES

In some of the best electric furnaces insulation has been brought to such a state of perfection that with the inside at from 2,200 to 2,500 deg. F., the outside of the furnace never reaches blood heat. This makes conditions better for the workmen, besides saving considerable money.

Heat insulation is made of various materials. Magnesia, asbestos, mineral wool, hair, felt, paper pulp, mica and other things may all be and are used more or less frequently. However, it is rather inadvisable to cover highly heated pipes with organic materials, on account of danger of fire, or in places where there is dampness, as most insulation of this kind will deteriorate rapidly if exposed to dampness or repeated wetting and drying.

J. S. F. Gard, B.Sc., A.I.C., in his presidential address before the British National Association of Industrial Chemists, January, 1919, gave the following table which he had prepared, showing the heat loss from a pipe lagged with 1½ in. of material and with steam inside at 400 deg. F. and air outside at 68 deg. F.:

Material	Loss in B.t.u. per Sq.Ft. per Hour
Magnesia	118
Blue Cape asbestos	121
Mica (best only)	123
White asbestos	126
Plastic, etc. (best)	133
Plastics, etc. (inferior)	143
No insulation	1,070

These figures, while not necessarily conclusive as to the insulating values of the various materials, show plainly the difference between even poor insulation and none at all. For with a pressure of 150 lb., no superheat if 856 B.t.u. are lost 1 lb. of condensed steam goes through traps to the sewers, and the full amount of fuel burned to heat it (⅛ lb. of coal if furnace losses are counted) is lost. Figure out the losses from the pipes in your plant.

Laying organic insulations aside for the reasons previously given, let us look at the mineral products with a view to learning something of their characteristics. These we shall divide into lasting qualities, manner of application, supports necessary, covering and protection.

Good mineral insulation should last almost indefinitely if well cared for. Magnesia coverings from the U.S.S. "Westcott," after having served for 24 years and been under water for four months, were salvaged and were said to be in as good condition as when new. Instances have been known where heat insulation improved in value as much as 3 per cent through many years of service.

Insulation is supplied in five forms, as dictated by the needs of the occasion of application—blocks, sections, segments, cements and insulating earth. Blocks are used for covering flat surfaces, large boilers and tanks. They are made in all convenient sizes and may be cut to fit. Segments, as their name implies, are curved blocks made for small boilers and tanks and large pipes.

For ordinary pipes in the smaller sizes, sections are made in standard lengths, each of which covers half the pipes, so that they are paired when the pipe is covered. Cement is used to fill up cracks and to coat over installations, bringing them up to the required thickness when that is between the thicknesses in which sections, etc., are supplied.

Insulating earth is usually powdered mica, asbestos or raw magnesia and is mostly used in cracks and bricked-in work, such as the sides of boilers and certain kinds of furnaces.

SUPPORTS USED FOR SPECIAL SHAPES

Supports are used in insulating things of special shapes, such as valve bodies and pipe flanges. They consist of wire forms of the shape desired, on which the insulating material is built up. Without these supports coverings would be unstable in some places and would be liable to crack loose. It is also customary to protect insulation with a canvas covering stitched on, and in many cases painted with two or three coats of paint of some suitable color.

It is important to insulate sufficiently, otherwise much of the possible good is lost. A one-inch layer of insulation is not sufficient for a pipe containing steam at 600 deg. F. However, no attempt will be made here to give the correct thickness of insulation for the various temperatures. These differ with different materials. The best way is to follow the advice of a reliable maker.

EDITORIALS

F. R. LOW, EDITOR

Poor Coal and the Smoke Nuisance

TOO often an excuse is offered or even accepted in place of a reason. Just now this seems to be true in many places where increase in the smoke nuisance has been blamed wholly on the quality of coal. Certainly, there are many plants which today are belching forth black clouds of smoke unnecessarily and being excused without reason.

There is no doubt that much of the coal supply offered today is inferior to that which the plant operator is ordinarily entitled to demand. Moreover, this is no time for quibbling over the fine distinctions between coals that are almost equivalent, for the supply in many parts of the country of good quality is by no means adequate. Nevertheless, this unfortunate aftermath of inexcusable coal-mine conditions should not result in unnecessarily slack methods of plant operation.

In times past many plant engineers have been disposed to work hard for smoke elimination through pride in the quality of their work, but there have always been an appreciable number whose efforts at smoke reduction were inspired more by the fear of the smoke inspector than by any other cause. Naturally, when the smoke inspector realizes that he cannot be so severe in his application of smoke ordinances as under normal conditions, these individuals, inspired only by the fear of the law, slack off in plant operation. It would be interesting, or perhaps it might be distressing, to know how many of the "waving plumes of industry" are now conspicuous because of this slackness of inspection.

Checking Results

THE greatest obstacle to reduced production costs in any factory is the absence of means of checking results. This applies with particular emphasis to the refrigerating plants, with but few exceptions.

It is by no means unusual to find plants of even large tonnage running along day in and day out with no check save upon the fuel consumed or the electric power purchased and the amount of cold-storage receipts or tons of ice sold. This condition is a direct inducement to low efficiency, for even if he would, the engineer is unable to find how well he is doing compared to what a plant should do under the existing pressure conditions. It is of little advantage to compare the results obtained in a particular plant with those recorded elsewhere, for the pressures are seldom the same.

It is impossible to say with any finality that a ton of refrigeration can be produced at the expenditure of a definite number of horsepower-hours, for the ideal requirement varies with the temperatures and pressures. For this reason, knowing the pressures carried in a plant, the results must be compared with the ideal results for like pressures. This has been done and is presented on another page in the form of a performance chart. By the use of this chart the favorability of the plant's records may be found directly.

The user of the chart must assume that the condenser pressure carried is the lowest obtainable. Often this is not true, and by a more liberal supply of condensing water or a cleaner condenser, or purging the system of air, the head pressure may be lowered a marked amount. The head pressure should not be the basis, but rather the temperature of the cooling water. Since it is impossible to have the ammonia, after liquefying, at the same temperature as the water, it is necessary to make an allowance, say ten degrees. Then if the cooling water is, say, sixty degrees, the ideal head pressure should correspond to a boiling temperature of seventy degrees. That the pressure actually recorded is above this indicates that ideal conditions do not exist.

Engineers in charge of even small refrigerating machines will find that by making use of the performance scale and correcting improper conditions so revealed, the cost of producing refrigeration will in many cases be reduced a surprising amount.

The Continuous Test a Business Necessity

IN A recent letter addressed to the editor of the *Engineer* (London), David Brownlie, a prominent British engineer, stated that American ideas in regard to boiler testing were far more practical than those in vogue in England or on the Continent. As an example of good tests properly conducted, he pointed to those recently made at the Connors Creek power station of the Detroit Edison Company. In contrast he held up to ridicule the British civil engineers' code, which permits tests as short as three hours. A test of this duration, he said, was utterly useless.

While American engineers will be pleased to hear that they have the right idea about conducting high-grade boiler tests, they will find the greatest food for thought in the statement ". . . in order to get the best results from any plant, it is essential to carry out tests from week to week continuously all the year round as part of regular routine." This remark was aimed at the British engineers, and the assumption is that American engineers are further advanced in this respect also. Probably that is true, but they have not always succeeded in convincing the business men, so that there is still much room for improvement in actual practice. There are still thousands of power plants—particularly industrial plants—in this country that are failing to avail themselves of the financial savings which continuous testing would make possible.

The purpose of the special test is to set the highest standard of economy obtainable with the given plant. To rest satisfied when such a test has been made is to mistake Utopia for an accomplished fact. A steam boiler has no inherent efficiency of its own. The results obtained depend to a large extent upon the skill and watchfulness of the operator. The same is true of the use of steam for heating and process work. Experience has shown that wherever this human element is an important factor, continuous records are needed if good

results are to be obtained. In his accounting and cost systems the business man has long kept such records of money and of the more tangible things for which money is spent, but he has paid little attention to the production and distribution of steam and electricity within the plant. The more progressive are coming to realize that, important as it is to record how much coal is obtained for a given amount of money, it is just as essential to know how much steam this coal produces, how much power is obtained from it and how much steam or electricity is used by each department.

There is just one way to get this knowledge. That is to arrange for the continuous measurement of coal, feed water, steam produced, steam used by various departments, power produced and power used. Such records are certain to lead to large savings at each stage of production and application with a cumulative effect at the coal pile.

Economical Possibilities of the Electric Steam Boiler

FROM a study of the economics of the electric steam generator it is evident that many users of hydro-electric power as well as the companies who are interested in the development of this source of power have not realized the possibilities of this class of equipment. However, the economic uses of electric steam boilers are now gradually being appreciated, and undoubtedly the next few years will see extensive installations. Although during the last ten years in Europe there have been over three hundred installations made in parts of the country where water power is available and coal is scarce, only within the last year or two have they been given any serious consideration in this country. There are installed or under construction in this country and Canada at the present time approximately 250,000 kilowatts of electric steam boilers. How far this development has gone is well exemplified in the two 25,000-kilowatt units installed in the Laurentide Company's plant and described in this issue. These units operate on 6,600-volt current and each has absorbed 35,000 kilowatts and when doing so generated approximately fifty tons of steam an hour.

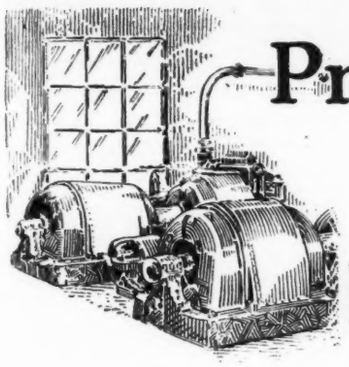
In considering the electric steam boiler, it should not be overlooked that its greatest possibilities are as a consumer of excess hydro-electric energy for which there is no market as power. Where the power development in a hydro-electric system can be sold on a kilowatt-hour basis for industrial and domestic purposes, the electric steam generator has little chance of competing with the coal-fired boiler as a generator of steam on an economic basis. However, after all these localities are eliminated there still remains large possibilities for electric steam generators. No better example can be given of what this equipment may mean to a power company that has excess hydro-electric power than that in the article referred to, where the installation resulted in increased revenue to the power company.

In considering proposed extensions to existing hydro-electric systems and in proposed new developments the possibilities of the electric steam generator should be studied. Even if there might be some doubt as to obtaining an industrial load for the full capacity of the plant, if part of the power can be sold as steam the additional revenue might assure the immediate financial success of the undertaking. Where all the works such as dams, tunnels, etc., have been constructed for bringing the water to the plant, the cost of obtaining additional capacity will be comparatively small, which might allow selling the excess power in the form of steam at a rate that would pay a satisfactory return on the additional investment and help to carry some of the charges on the initial investment for the power load. Then there are the opportunities of increasing the load factor on hydro-electric plants by selling excess power during off-peak periods. This also applies to the power consumer, where large blocks of power are purchased on a flat rate. Where industries develop their power from water-power sources, any excess can be economically utilized for steam making, unless there is no market for the power as such.

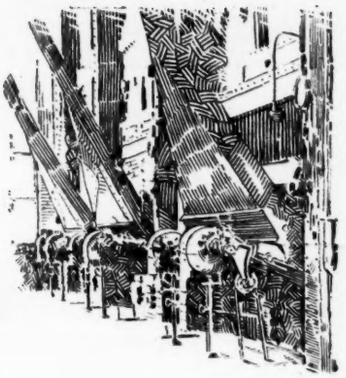
After a hydro-electric development is made, it does not cost any more to operate it at full capacity than at part load if the water is available. Since the construction of the steam generator itself is simple, no transformers being required until very high voltages are encountered, and the regulating equipment is simple, the cost is much lower than would otherwise be the case. Therefore it is comparatively cheap to install and operate and should prove attractive as a means of improving the load factor of water-power plants. It would be difficult to evaluate the economic possibilities of the electric steam generator at this time, but it has gone far enough to warrant serious attention.

The Coal Commission seems to have escaped the Jonah that has so persistently followed others who have attempted coal mediation. Its success in persuading operators and miners to extend their wage agreements until April 1, 1924, is regarded by many as a diplomatic victory. Fuel Administrator Garfield became the goat of a combination of adverse circumstances. The Federal Trade Commission, in taking a hand in coal affairs, became involved in a litigation that resulted in its powers being denied by the courts. The Robinson Commission granted the miners a big increase in wages and, as a result, was grilled by the operators and even by the mine workers themselves. Vacation strikes followed the anthracite ruling in 1920. The only reward that Secretary Hoover received for negotiating a voluntary agreement, without power or money, which saved the consumers of coal many millions, was bitter criticism as an abettor of profiteering. Criticism also was directed toward Fuel Distributor Spencer because he could not repeat the miracle of the loaves and fishes and make twenty cars of coal out of one. The Interstate Commerce Commission has had troubles galore as a result of its priority orders. But in spite of the bad luck that has pursued everyone who has touched coal, it has remained for John Hays Hammond and his associates to draw commendation where equally earnest efforts hitherto have drawn only criticism.

The explosion of a welded shell cooler in an ice plant at Detroit will serve to focus attention again on the question of welding for unfired pressure vessels. Investigation in this case showed imperfect welding to the extent in spots of only one-third the thickness of the shell. That good and safe welding is possible and is being done every day is generally acknowledged, but how is the purchaser of a welded pressure vessel to check the human factor involved, aside perhaps from the reputation of the welder—itself a difficult thing to define in codes or laws?



Practical Ideas *from* Practical Men



Importance of a Valve Shop in an Industrial Plant

Opinions vary as to the value or necessity of maintaining a valve shop in connection with an industrial plant, because few people realize the importance of such a shop. In my opinion all new valves when received should be tested before being taken into stock; likewise, old valves that have been repaired should be tested before being put back in service. A test arrangement consisting of a small pump and a few fittings makes it possible to test all valves before they are placed in stock.

It is also important that a man who is capable of repairing valves and who has had experience in this line of work be placed in charge of the shop. Old or leaky valves should be taken out of the line and put in storage until there is time to repair them. In many cases these valves are worn beyond repair, in which case some of the parts may be used on other valves.

The repairing of valves requires more than ordinary experience, although this is not realized by many engineers. Too often new valves are bought instead of repairing old ones. In some plants, however, there are a great many valves in use—as for instance, in a petroleum refinery or in a chemical plant. In an ordinary plant an investment of $30,000 to $40,000 is often required for valves alone.

In every well-managed plant one will find a stock of valves in the storehouse sufficient to meet all requirements, and there is a natural tendency to use new valves in all work instead of making use of old valves that could be repaired and made practically as good as new. A valve shop, where new valves can be tested and inspected before being sent to the storehouse and where old valves can be looked over regularly, should be maintained in every plant in which the quantity of this work is sufficient to keep a man or more busy.

Let us consider, for instance, a power house with ten or twelve boilers. When boilers are cleaned, say once in forty or fifty days, it is advisable in some cases to have every valve taken off to be cleaned and looked over in the valve shop, where there are tools and equipment to do whatever work is needed. After the valves have been overhauled, they should be tested and sent back to the boiler house, ready to be put back on the boiler. Blowoff valves or stop-cocks, in particular, need attention. This overhauling should be done in place where there is a skilled and experienced man in charge, who can look for loose stud bolts, defective seats and disks, leakage, etc. It is not advisable to have this overhauling done in the boiler house by a fireman or boiler washer. For the sake of safety it is important to have the boiler blowoff valves, feed-water valves, superheater drain valves, non-return stop-valves, etc., overhauled every time a boiler is taken out of service. Once the habit is formed, it is easy to follow the rule.

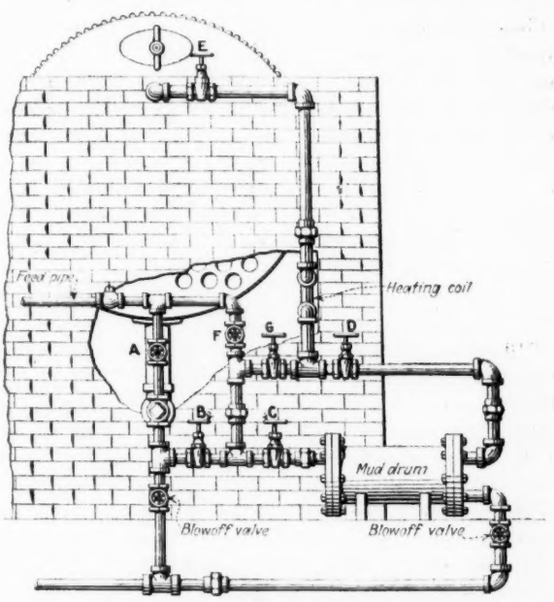
In case the valve man has no work in the shop, he can go around the plant, say once a week, and look over all the valves in the various lines. Sticking stop-cocks can be oiled and leaky stuffing boxes packed. The whole plant will be benefited when this is done, and the chances of having leaky valves will be greatly reduced. In many plants where the valve man is a specialist in his work, such a valve shop has brought about a great saving of money.

F. C. HEYLMAN.

Martinez, Calif.

An Improvised Feed-Water Heater

The sketch shows an apparatus that an engineer used for preheating the water fed to a horizontal return-tubular boiler. As originally arranged, the cold feed water was piped directly to the blowoff connection. In order to impart some heat to the water before it entered the boiler, the engineer decided to send it through a coil of pipe inserted in the combustion chamber.



FEED WATER IS PASSED THROUGH HEATING COIL PLACED IN REAR COMBUSTION CHAMBER

The gate valves *B*, *C*, *D* and *E* being open and *G* closed, there is an upward circulation of the boiler water from the blowoff connection through the mud

drum and heating coil to the top connection just above the tubes. The globe valve *A* being closed and *F* open, the feed water mingles with the circulating current of boiler water. By closing valves *C* and *D* and opening *G*, the circulation is directly through the heating coil. In the event of an accident to the coil, the whole arrangement can be cut out, and the feed through the blowoff connection resumed, by closing valves *B*, *E* and *F* and opening valve *A*. A. J. DIXON.

St. Louis, Mo.

Change of Lubricating Oil Causes Trouble in Semi-Diesel Engine

Often the trouble an engineer gets into with new machinery is traceable to failure to follow the builder's suggestions. This is especially true as to the lubricating of oil engines.

Some time ago two 25-hp. semi-Diesel engines of the two-stroke-cycle type were installed in a small light plant. For about two months the engines ran well. The erector had purposely left the feeds of the lubricator set above normal, saying that this could be reduced when the engines limbered up. The builders had recommended a very limited list of high-grade and rather expensive lubricating oils. However, another engine of the same make had been running some four years on a much cheaper grade and we changed over to this oil without trouble. An oil salesman persuaded us to try a still cheaper oil which he said was just as good. At about the time we made this change in oil, we also cut down the lubricator feeds to those specified by the instruction book.

One evening one engine showed signs of heavy load; it pounded, smoked heavily, and finally, with a few terrific explosions, stopped. The starting torch was going in a few minutes and the engine started without trouble. No reason was found. But the trouble recurred, always at the same time. The second engine followed suit. Both grew worse. The black smoke indicated the engines were not getting enough air. We removed the air intake valve, a large leather-flap affair, and found several flaps stuck down with a sort of gum. We removed this and the engine ran well for a number of hours after which the trouble was repeated, the flaps again being found stuck down. The builders' sales agency, 350 miles away, could not offer any suggestion, except that we might send in the gum for examination. The trouble continued; punctually each evening, although the engines did not overheat and the lubricators were working, the engine pistons began to stick.

Finally, both engines stuck fast. We called another erector. He told us the engines were ruined, having seized both pistons owing to bad oil. A one-ton triplex Yale block was used to break the pistons loose in the cylinders. Both pistons and cylinders were found deeply scored. The engines ran well enough when cold and under light load, but the arrival of the peak about the same time each evening caused enough expansion in the piston to seize.

The surface of the pistons appeared to have been casehardened, and the files used to dress down the scores wore rapidly. The worst scoring was on the bottom of the pistons, indicating that the oil fed into the top of the cylinder was destroyed by heat before reaching the bottom. After dressing the cylinder walls with a rounded abrasive block, the erector warned us to get new cylinders and pistons at once, since he said the old ones were as good as gone. However, after changing back to the oil originally recommended by the engine builders, the engines ran well. We ordered a spare cylinder and piston, but the engines ran so well with the old cylinders and pistons that the new ones were sent back. The operation of the old pistons seemed to indicate that extremely close clearances and fine ground finish are unnecessary.

The cause of the trouble was insufficient lubrication at a critical point, and no doubt the lubricating oil company should be criticized for having salesmen who recommended oils without sufficient knowledge of plant conditions. COLIN K. LEE.

Bowling Green, Mo.

Flywheel Pounding

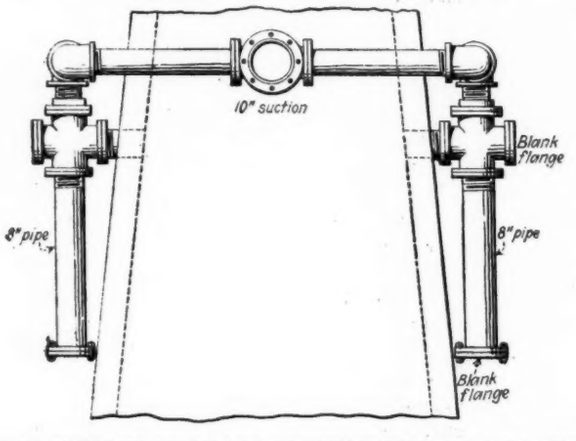
My first experience with a flywheel pounding was while I was engineer in a factory. One night the air compressor began pounding. The sound traveled and was misleading. Upon investigation I found the setscrews and key loose. As soon as these were all tightened, the pounding ceased.

My second experience of this kind was with a 150-hp. engine driving a generator. Every time the load varied, the engine would pound and then quit. We thought it was the governor, so we fitted new ball bearings on the fulcrum pin and a new rubber bumper in the flywheel rim, but this did not stop the pounding. One night while I was on duty, I recalled my first experience with the air compressor. I tightened up all the setscrews and drove the key up tight. This cured the trouble, and the engine ran as quietly as ever.

San Jose, Calif. ROY E. GRAVES.

How the Coke Dust Is Removed From Compressor Suction

In the operation of a compressor used in process to carbonate juices in sugar manufacture, we experienced considerable trouble from coke dust that came over from the kiln. To overcome this, we installed traps in the suction line to catch the dust at the kiln. This eliminated the settling in the horizontal piping and the clogging of the screen in the gas washer. Pieces of 8-in. pipe were connected in the suction as shown, with blank flanges on the bottom to facilitate cleaning. These flanges are removed and the pipes cleaned every 24 hours. HERBERT HUGHES.



DUST SETTLES IN TRAPS CONSTRUCTED OF 8-IN. PIPE

Burley, Idaho.

Comments from Readers

Internal-Combustion Engines, Applicable to Small and Medium-Sized Central Stations

I have read with considerable interest, articles recently appearing in *Power*, on the subject of oil and gas engine operation, and detailed descriptions of various installations in industrial plants and central stations. I believe these articles are eagerly read by all engineers and others interested in economical power production.

Owing to the increasing tendency toward higher cost of all kinds of fuel commonly used today, and diminishing supply, it is reasonably certain that conservation will become a matter of forced necessity. In the early days of central-station development, the type of prime mover was selected more from a viewpoint of reliability, simplicity and low first cost, than from a consideration of efficiency, as coal was then cheap and economy in consumption of fuel was not of such paramount importance as today. As the internal-combustion engine was not highly developed then, the choice was steam power of some type. The resulting inefficiency of such plants made high rates necessary to support operation, and profits were uncertain. Many of these small municipal and privately owned utilities have solved the problem of power by purchase from the large central station. Others have substituted oil and gas engines and have gotten highly improved efficiency in operation and, where once nearly all revenue was dissipated in fuel bills, now are in positon to show decided profits from the operation of their plants. A vast amount of research and experiments have been in progress in recent years, in the development of oil and gas engines, and the increasing number of installations is evidence of considerable favor in selection and the advantage of this type of power is now a well-established fact. The instability of crude and fuel oil prices was formerly argued against the wisdom of investing large sums in oil engines; however, it is reasonable to suppose that there will never be any considerable variation in cost of oil and coal, and the balance will be in favor of the oil engine owing to its higher efficiency and its ability to utilize a much larger percentage of the heat energy of the fuel than is possible with highest class steam power.

The difficulty experienced in operation of the early Diesel and semi-Diesel engines, was due probably as much to the general lack of understanding on the part of operatives, as to faulty design or construction. They will require careful attention, but no more skillful attention that a steam plant. Internal-combustion engines of all kinds should be installed with particular care to the cooling system. Water tending to lime up the jackets should be avoided, and the circulation should be continuous and positive in operation. The oiling system should be given the utmost care. Owners should not buy Diesel engines with the idea that anybody can run them. The operator should be a fair mechanic and one having made some study of this particular type of machinery. The immense saving in fuel in fair-sized power plants, effected by the use of oil and gas engines, will fully justify large investments in engines and also will justify employment of the most skillful attendants.

Too many power plants today are operating for the joy in paying big fuel bills that dissipate all or nearly all of the profits, and the question that will decide success or failure, or profit or loss, will be the facilities for cheap generation of power. The internal combustion engine is probably just coming into its own.

Stroud, Okla. JOHN A. WALKER.

What Is a Double-Beat Valve?

I have read with much interest the several articles recently appearing in *Power* on valve gears of unaflow engines. All makes described employ poppet steam valves with double seats. All save one of the valves had two seats in different planes, and you have called such valves, as is customary, "double-beat" valves. However, the article in the issue of Nov. 14, 1922, describing the Chuse unaflow refers to the valve as "single-beat." This valve, like those of the other unaflows described, has two annular seats, and although these seats are in the same plane the valve gives double admission of steam and requires the same lift as the usual form, and is therefore essentially equivalent.

I raise the question as to whether the terming of the Chuse valve single-beat is not a misnomer; or whether at least it does not lead to a misconception. I believe I am correct in stating that the term "double-beat" had its origin with reference to the double-seat valve as used in the Cornish pumping engine. This valve had seats in different planes and was practically like the usual double-beat valve of the present day. The single-seat or single-beat valve, as ordinarily understood, has one annular seat; and for the same effective port opening with the same diameter it requires double the lift of the double-seat valve.

Would it not be well to use terms that are not misleading and to call the Chuse valve double-beat or double-seat, as it is? It certainly contacts with two seats and thus presents the same linear possibility for steam leakage as does the usual spool-shaped double-seat valve. The Chuse valve is not a balanced valve, as is the other type; its diameter for the same port area is larger than the usual type; and although the placing of the two seats in the same plane is supposed to reduce the distortion due to expansion and contraction, as affecting steam tightness, the double seat where a solid valve is used actually does not overcome the tendency to leakage.

The only truly single-beat valves described in these several articles are some of the exhaust valves which have single seats. R. C. STEVENS.

Erie, Pa.

[It would be interesting to learn what term engineers would use to designate a lift valve having two seats located on the same plane.—EDITOR.]

Behavior of A.-C. Generators When Field Circuit Is Opened

I read with interest G. C. Newell's comments in the Jan. 23 issue on the action of an alternating-current generator when its field circuit is opened.

There are in our plant three turbo-alternators of 10,000, 7,500 and 4,400 kw. capacity respectively. The 10,000-kw. machine was being taken out of service to have its condenser tubes cleaned, and the 4,400-kw. machine was brought up to speed and connected in parallel with the other two units and the 10,000-kw. generator shut down. By the time that all adjustments incident to the change over had been made, I began to smell insulation burning and upon investigation found that the relay and closing coil of the remote-controlled field switch on the 4,400-kw. machine were still in circuit. The closing-coil button had stuck and kept current on the coil and burned it out.

Apparently, the easiest way out of the trouble was to trip the breaker and close it again by hand, and as it was Saturday afternoon this move could not cause much inconvenience. When the field breaker was tripped, the 7,500-kw. machine took the load and the 4,400-kw. machine remained on the line with its field circuit open, with its ammeter indicating 250 amperes. The only effect experienced was a dip in the voltage, which was taken care of by the Tirrill regulator. H. M. FRIEL.

Wilmington, Del.

Hints on Being Chief Engineer

The article in the Jan. 2 issue by G. A. Bristow appeals strongly to me and vividly reflects some of my past experience in this line, and after some 35 years as engineer, during which time I have held some important positions as chief engineer, I feel qualified to offer some suggestions to the young engineer regarding some of the necessary qualifications.

One thing important for him is to respect the knowledge of his subordinates if he expects them to respect his knowledge. Learn to have no favorites; see that every man gets a square deal; listen to suggestions, and when offered, if not approved, say frankly you do not approve them, and tell why; treat oilers and wipers with the same respect you would a shift engineer—they deserve it, for they are the men who eventually become shift engineers in a properly managed plant. Let the operating crew operate the plant; that's what you have them for.

If you see a man make a mistake at the switchboard or anywhere else, do not reprimand him in front of others, but call him to your office and let him know that you observed his mistake. He will appreciate it and try to avoid a repetition. If you do not employ a regular switchboard operator, make it the duty of some one man on each watch to operate the board. Don't try to do it yourself. Have your crew well organized, so each man knows his place and knows just what to do and what not to do. Under all conditions do not neglect to call a man's attention to any mistakes that you observe, and hold every man strictly accountable for the duties he is to perform, and you will soon find that you have an efficient operating crew who will respect you as a chief.

I have found from experience that the best thing to do, when taking charge of a plant with which you are not familiar, provided the retiring chief has left the plant before you get there, is to instruct all help to continue operation just as they have been accustomed to until you have time to look around and get a lineup on the equipment. Then if you wish to make any changes, you will be qualified to do it intelligently. Study your men carefully, treat them well, and if you find you have one who can't stand for that, get rid of him. There are such men. Insist that every man about the plant be as familiar with all details as possible. There is no danger of anyone's learning too much, and just as soon as the men acquire thorough knowledge, place duties on them requiring the use of this knowledge. A really ambitious man appreciates responsibilities. H. R. ROCKWELL.

St. Louis, Mo.

What Causes Black Spots on the Commutator?

It is impossible to give a definite answer to the question asked by Mr. Macrea in the Oct. 31, 1922, issue as to what causes black spots on the commutator of a three-wire direct-current generator, since the design of the machine, the particulars of the station layout and the operating conditions are not known. The following remarks cover, in a general way, some conditions that cause blackening of commutator bars and suggestions for remedying that trouble:

A commutator that is in poor condition—that is, one that is rough or one having high or low bars or high mica—can cause blackening of commutator bars at points on the commutator where it is in bad condition. This is, of course, due to the current burning the commutator at these points because of the poor brush contact. Tightening and grinding the commutator and undercutting the mica between bars will overcome this difficulty. A commutator should always be heated by being run under load before being tightened.

Unequal distribution of current in brush arms due to poor joints in the brushholder cross-connections or unequal distribution of currents in the brushes due to weak spring pressure or the sticking of brushes in their holders or rough or broken brushes will cause heavy overloads on part of the brushes and small currents in the others. The heavily overloaded brushes will cause burning and blackening of the commutator. The remedy in this case is to clean and tighten all joints and see that all brushes and holders are in good condition and that the brushes work freely in their holders and have the correct spring pressure.

Unfavorable electrical conditions due to the construction of a machine can cause blackening of certain commutator bars. Fig. 1 shows an armature slot with six conductors or three coils per slot, three segments of the commutator and the brush. Conductor *A* is connected to bar *a*, *B* to bar *b* and *C* to bar *c*. The commutator bars of any machine are equally spaced, but the conductors in the armature are not necessarily symmetrically located around the periphery of the core, as can be seen from the sketch. When the conductors in any one slot have all passed a given point, it will be apparent that not all of the commutator bars connected to these conductors have passed a given point. This means that the different coils in a slot commutate at different positions in space or, in other words, in different parts of the commutating-pole field. Also the self and mutual induction effect of conductor *B* is different from that of conductors *A* and *C*, owing to its

different location in the slot. Thus, with these conditions different in each conductor, one of the conductors will commutate under more unfavorable conditions than any other conductor in a given slot. If the conditions are such that the conductors operating under the best conditions are just within the limits of successful commutation, then that conductor which operates under the most unfavorable conditions will spark at the brush during commutation. This sparking and burning will occur at definite fixed intervals on the commutator.

This trouble can often be minimized or completely eliminated by shifting the brushes so that the conductor operating under the most unfavorable conditions, will operate under a different part of the commutating-pole field, or in the case of a non-interpole generator, under a different part of the edge of the field produced by the main pole. Very often a change of grade of brush will completely overcome commutator-bar blackening, for the grade of brush on the machine may not have all the characteristics to handle completely the load current and short-circuit current of the coil undergoing commutation.

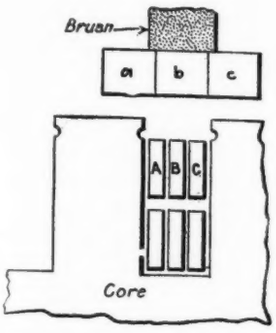


FIG. 1—THREE COILS IN ARMATURE SLOT

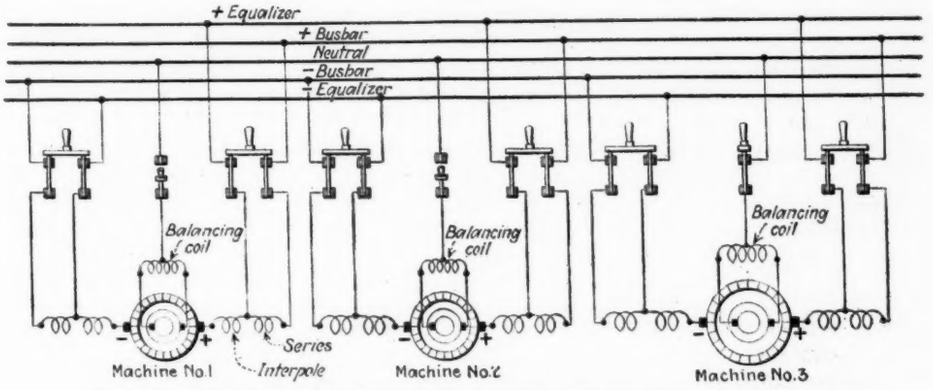


FIG. 2—THREE THREE-WIRE GENERATORS CONNECTED IN PARALLEL WITH NEUTRAL OPEN ON THE TWO SMALL MACHINES

In the case of three-wire generators operating without unbalanced load, the conditions would be the same as with a two-wire generator. No alternating current flows in the main neutral leads of the generator and thus none can flow in the direct-current brushes of the machine as suggested by A. S. McClain, on page 894, Dec. 5, 1922, issue. Since the alternating current which flows in the balance coil and in the armature winding of the direct-current machine completes its circuit through the slip rings of the machine and does not in any manner flow through the direct-current brushes of the machine, it cannot cause blackening of the commutator bars, and it is immaterial in this respect what its frequency is. Thus, two three-wire machines operating in parallel, each of which generates a different frequency in its armature winding, cannot have the commutator bars blackened due to this alternating current.

From Fig. 2 it can be seen that the balance coil has an alternating current flowing in it because it is connected to the collector rings of the armature. This is only a small exciting current and may be compared to the current flowing in the primary of a transformer when it is operating with the secondary on open circuit. Besides this alternating current there is a direct current that flows in the balance coil when the generator is carrying unbalanced load. This current, for all practical purposes, can be assumed to divide equally and one-half flow through each part of the balance coil.

It is possible for a three-wire generator to operate without blackening the commutator bars when carrying no unbalanced load and to blacken the bars when carrying unbalanced load. The unbalanced load may be sufficient to overload a brush just on the point of sparking and cause it to spark and blacken the commutator bars. When a machine is carrying an unbalanced load, one set or polarity of brushes will be carrying more current than the other set or polarity of brushes and will necessarily require a different interpole or commutating pole field than the other set. This is not obtained, although a compromise condition is attempted by connecting the commutating-pole coils so that one-half of them are connected in the negative lead of the machine and the other half in the positive lead. This will give a field weaker than actually required for the side carrying the greater current and stronger than required for the side carrying the smaller load.

In the case of three-wire machines operating in parallel, the same results would be expected of two identical machines operating in parallel as when either machine is operating alone, and if neither machine gives any commutation trouble when operating alone, none should be expected when they are operated together. If, however, the machines are of different capacities or of different designs, they may not operate satisfactorily in parallel, for one may carry more than its proportional share of the total load and this may overload one machine and cause blackening of its commutator bars. This may be the cause of the trouble with the three generators before mentioned. If No. 3 machine is operating alone and carrying its rated load or even an overload and No. 1 or No. 2 is connected in parallel with it, the latter may take more than its share of the unbalanced load, especially since it is of only one-half the capacity of the larger machine. This can be easily determined by installing ammeters in the lead from each balanced coil.

In this case it would probably be better to operate these three machines with all the unbalanced load carried by the larger machine or by the two smaller machines in parallel. This can be done by leaving the neutral wire switch of machines Nos. 1 and 2 or of No. 3 open when all are in parallel. Where the unbalance load is too great for No. 3 machine or Nos. 1 and 2 machines in parallel to handle alone, the plant circuits should be rearranged so as to bring the unbalanced load within the capacity of the machine.

East Pittsburgh, Pa. CLARENCE LYNN, Engineer.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Operation of Ammonia Refrigerator

Why is it necessary to raise the pressure and temperature of ammonia gas by compression in order to extract heat from the gas? E. H. T.

In performance of refrigeration, the heat absorbed by the liquid ammonia is the latent heat of evaporation at the suction pressure. By compression the pressure of the ammonia gas is raised to a value such that the temperature corresponding to the pressure is more than the temperature of the condenser cooling water. Consequently, the cooling water will absorb heat from the gas and the gas is deprived of its latent heat and liquefies, in which form the ammonia flows to the evaporating coil at a low pressure, ready to absorb a new supply of heat in repetition of the process of refrigeration.

Equalizing Corliss Engine Cutoff

How can the points of cutoff in opposite ends of a Corliss engine cylinder be equalized where, with the average load, the cutoff of one end is at ¼, and the other at ½ stroke? D. J. D.

The same load would require cutoff at about ⅜ stroke from both ends of the cylinder. Place the piston at ⅜ stroke from one end of the cylinder and raise the governor slowly until the steam valve on the same end is tripped by the cutoff cam. Block the governor in this position and place the engine at ⅜ stroke from the opposite end.

For equality of cutoffs the governor reach rod to the valve must be adjusted in length to obtain cutoff at that end also. If cutoff takes place before ⅜ stroke has been accomplished, or has not taken place, lengthen or shorten the reach rod so it will not take place at ⅜ stroke and gradually adjust the length of the reach rod so the valve will be tripped with the piston in that position. Then block the governor a little lower and test whether the cutoff is alike at both ends.

On account of the angularity of the connecting rod, a given fraction of stroke, less than one-half, from the head end is accompanied by less angular movement of the crank and eccentric than for the same fraction of stroke from the crank end. In consequence of this and of the angularity of the valve-gear connections, adjustments for equalization of the cutoffs for a particular position of the governor will not obtain equalization for other governor positions. Hence, for a change of the point of cutoff required for a change of load or by a change of initial steam pressure, equalization of the cutoffs cannot be preserved. The best that can be done is to make the adjustments for obtaining equal cutoffs for the average conditions of load and initial steam pressure, checked by indicator diagrams.

Saving from Use of Feed-Water Heater

Where steam is generated at 100 lb. gage pressure, and the boiler-feed water is supplied at 60 deg. F., what percentage of saving would be obtained by use of an exhaust steam feed-water heater that would raise the feed-water temperature to 200 deg. F.? F. L. R.

A pound of dry saturated steam at the pressure of 100 lb. gage, or 115 lb. per sq.in. absolute, contains 1,188 B.t.u. above 32 deg. F. For generation of steam from feed water at the temperature of 60 deg. F., each pound of feed water must receive 1,188.8 — (60 — 32) = 1,160.8 B.t.u. By raising the feed-water temperature to 200 deg. F., the boiler will have to supply 200 — 60 = 140 B.t.u. less per pound of feed water, so that the heat saved for generation of the same amount of steam would be $(140 \times 100) \div 1{,}160.8 = 12$ per cent.

If the use of the exhaust results in an increase of engine back pressure, more steam will be required for developing the same power. Under average conditions the greater quantity of steam required for two or three pounds increase of the average back pressure would be substantially the same as though the load on the engine required the same increase of the m.e.p. and the increased steam consumption would be practically the same percentage that the increase of back pressure is of the average m.e.p. For instance, if the load requires 40 lb. m.e.p. and the engine back pressure is increased 2 lb., the steam consumption would be about $\frac{2}{40}$, or about 5 per cent. Hence by raising the feed-water temperature from 60 deg. F. to 200 deg. F., the heat required for generation of steam supplied to the engine would be $(100 - 12) \times 1.05 = 92.4$ per cent as much, or a saving of about 7½ per cent.

Cause and Prevention of Clinker Trouble

We burn soft coal in a small horizontal return-tubular boiler and experience trouble with clinker spreading over the grates. What is the cause of clinker trouble and how can it be prevented? F. J. F.

Clinker is formed from the melting to a slag and subsequent cooling and solidifying of combinations of substances that are present as ingredients of the fuel or that may have become mixed with the fuel. In boiler furnaces the slag comes from such impurities in the coal as iron, sand, clay, lime, sulphur and magnesia. The sand, lime, etc., when heated together, form a pasty fluid mass like melted glass, but irregular in composition and varied in color after cooling, according to the impurities that are present. This slag flows over the ash and other ingredients that are not melted and, when cooled, cements the particles together, forming the rough mass called clinker.

To make a slag, an acid substance must be heated with a basic substance. Sand, lime, clay, etc., when heated alone will withstand much higher temperatures than exist in boiler furnaces, but when heated together will melt easily and in some cases make a thin and very fluid slag; but when either the sand or the base is greatly in excess, a much higher temperature is required to do the melting. Hence, to hinder the clinkers forming, add some limestone, magnesia rock or oyster shells to the fire.

A thick fuel bed generally causes clinker trouble, as it cuts down the air supply and permits the ash to become heated and fused together. Another cause of clinker trouble is stirring the fire by thus bringing the ash to the hotter part of the fuel bed where it fuses and produces clinker.

To aid in overcoming clinker, use thin fires; keep the fire bed level by placing the fuel on the thin spots. Do not level the fire with a rake or break and mix up the fire with a slice bar. Have the ash on the grates kept as cool as possible so it will not become cemented together into a clinker. Keep the ashpit clean. A jet of steam or water kept in the ashpit will help greatly. If possible, keep the ashpit doors open and use the damper to regulate the draft.

Testing Tightness of Heating System Check Valves

With no fire in a heating boiler how could a test be made of tightness of a check valve in the returns, or of a check valve on the boiler; and of what benefit is a check valve on a boiler in addition to preventing the water from leaving the boiler? G. H. P.

The simplest test of tightness of the check valve on a cold boiler would be to close the nearest stop valve on the return main, fill the boiler with water above the glass gage or highest gage cock, and determine whether the water level falls when the return stop is opened and the system is vented back of the return stop. To test a check valve on a return line, close the nearest stop valve in the return line on the boiler side of the check valve that is to be tested, then determine whether an intermediate connection between the check valve and stop valve can be kept filled with water under a head of five to ten feet above the level of check that is under test while the return pipe on the entrance side is vented by opening an air valve or other connection. In addition to preventing water from backing out of a boiler, a check valve is beneficial in preventing loss of heat by circulation of the boiler water in return lines that are below the boiler water level.

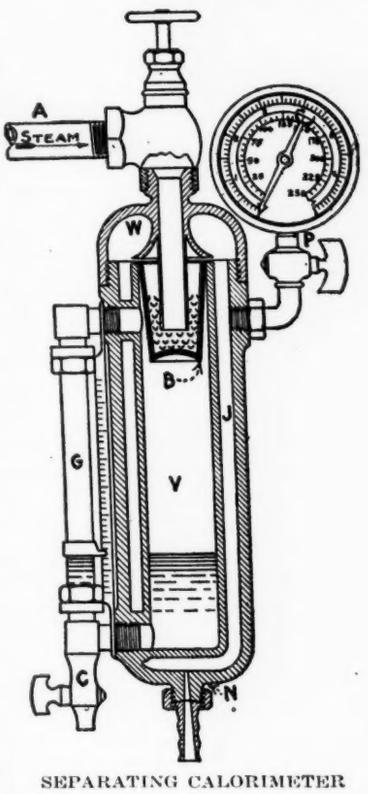
Operation of Separating Calorimeter

What is the method of operation of a separating calorimeter for determination of the percentage of dryness of steam? R. C. N.

The entrained water in a sample of steam is removed by mechanical separation just as in the ordinary steam separators. The water is collected in one part of the calorimeter and the moisture-free steam passes off at another part and their separate weights are obtained.

A sectional view of the instrument is shown in the figure.

Steam to be tested, supplied through a pipe *A* is discharged into a cup *B* with perforated sides. Here the direction of flow is nearly reversed, causing the moisture to be thrown outward through the meshes of the cup into the central chamber *V* that is provided with a glass gage *G*. The dry steam passes upward through the spaces between the webs *W* in the top of an outside jacketing chamber *J*, and finally is discharged from the bottom of this jacket space through the nozzle *N*. This nozzle is considerably smaller than any section through which the steam flows, and there is no appreciable difference between the pressure on the central chamber *V* and the jacket space *J*. The scale opposite the gage glass *G* usually is graduated to show in hundredths of a pound the variation of the quantity of the water accumulated. The inner graduations of the gage *P* indicate the pressure in the jacket *J* and outer graduations of the dial usually are laid off to show the weight of steam flowing through the nozzle *N* during a period of 10 minutes.



SEPARATING CALORIMETER

A petcock *C* is used for draining the water from the instrument and by weighing the water collected corresponding to a given difference of level in the gage *G*, the scale opposite it can be readily calibrated.

Too much reliance should not be placed in the readings for the flow of steam as indicated by the gage *P* unless it is frequently calibrated. Usually, for determining the weight of dry steam discharged, it is very little trouble to connect a tube to the nozzle *N* and condense the steam in a large pail nearly filled with water. When a test for quality is to be made by this method, the pail nearly filled with cold water is carefully weighed and then at the moment when the level of water in the water gage *G* has been observed the tube attached to the nozzle *N* is immediately placed under the surface of the water in the pail. The test would be stopped before the water gets so hot that some weight is lost by evaporation.

If W = the weight of water removed and w = the weight of steam discharged at *N* in ten minutes, as indicated by *P*, or condensed during the same time that the quantity of water *W* was removed from the sample of steam to be tested, then $W + w$ = the total weight of steam taken in at *A* and $w \div (W + w)$ = the quality of the steam.

As an example, suppose the quantity of water collected in a certain time was 0.15 lb. and during the same time the weight of dry steam discharged or caught as condensate was 2.6 lb., then the quality of the sample steam received at *A* would be $2.6 \div (0.15 + 2.6) = 0.944$ or 94.4 per cent.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses.—Editor.]

Easy Lessons in Engineering

Ratio and Proportion in the Power Plant

The "ratio" of one number to another is merely the first divided by the second. So the ratio of 1 to 5 is $1 \div 5 = 0.2$.

There are two common ways of writing a ratio. For example, the ratio of 1 to 5 may be written either as 1 : 5 or as $\frac{1}{5}$. The latter may be used for the reason that the value of any fraction is the numerator divided by the denominator, which fits the definition just given for a ratio. In the same way the ratio of 5 to 2 may be written 5 : 2 or $\frac{5}{2}$, and its value is $5 \div 2 = 2.5$.

If a boiler has 1,800 sq.ft. of steam-making surface and 46 sq.ft. of grate surface, we may say that the ratio of steam-making surface to grate surface is 1,800 : 46, or $\frac{1,800}{46}$, or $1,800 \div 46 = 39.13$. Reversing the ratio, we may also say that the ratio of grate surface to steam-making surface is 46 : 1,800, or $\frac{46}{1,800}$, or $46 \div 1,800 = 0.0255$.

Now suppose we wish to build a larger boiler with the same ratio of grate surface to steam-making surface. We may write:

Ratio for small boiler = ratio for large boiler

46 : 1,800 = grate surface of large boiler : steam-making surface of large boiler

If the steam-making surface of the larger boiler is to be 2,200 sq.ft., this becomes:

46 : 1,800 = grate surface of large boiler : 2,200

We have here a good example of what is called a "proportion," which is a problem where two ratios are known to be equal. The rule for solving a proportion is this: "The product of the *means* equals the product of the *extremes*." The *means* are the two inner quantities, those closest to the equality sign, while the *extremes* are the two outer quantities.

Applying this rule we get:

1,800 × grate surface of large boiler = 46 × 2,200

1,800 × grate surface of large boiler = 101,200

This is what is called in algebra an equation, but it takes no knowledge of algebra to solve it. Only a little common sense is needed. If 1,800 × grate surface = 101,200, it is evident that the grate surface is $\frac{1}{1,800}$ of 101,200, or $101,200 \div 1,800 = 56.2$ sq.ft.

The same rule of "means and extremes" will solve any proportion. For example, the weight of a given-size pipe is in proportion to its length. That is to say, the ratio of any length to its weight is equal to the ratio of any other length to its weight. As a practical application suppose that we want to find the weight of a section of pipe that is to be replaced, the section having a length of 27 ft. 6 in. = 27.5 ft. Although it is not possible to weigh this length, there happens to be a short section of the same pipe in the pipe rack. This is found to measure 4 ft. 9 in. = 4.75 ft., and to weigh 17 lb. 8 oz. = 17.5 lb. Then we can write:

Weight of long piece : length of long piece = weight of short piece : length of short piece

Weight of long piece : 27.5 = 17.5 : 4.75

Putting the product of the means equal to the product of the extremes, we get:

27.5 × 17.5 = 4.75 × weight of long piece, or

481.25 = 4.75 × weight of long piece.

Using only four significant figures[1] we may write:

4.75 × weight of long piece = 481.3.

Weight of long piece = 481.3 ÷ 4.75 = 101 + lb.

If the reader is familiar with algebra, he may call the weight of the long piece W and write the proportion as follows: $\frac{W}{27.5} = \frac{17.5}{4.75}$.

Another way to solve this problem, and one that has the advantage of being clearly understood at every step, is to figure the weight per foot of the short pipe and use this to figure the total weight of the long pipe.

Inverse proportion may be illustrated by the case of one pulley belted to another. In that case the speeds are said to be inversely as the diameters, or in inverse proportion to the diameters. This may be written:

R.p.m. large pulley : R.p.m. small pulley = Diameter small pulley : Diameter large pulley

It will be noted that the order of large and small pulley is reversed in going from one side of the equality sign to the other. It makes no difference what the actual order is, as long as the order on one side is the reverse of that on the other. As an example of such a problem, suppose that it is desired to find what the r.p.m. of a 12-in. pulley would be if belted to a 20-in. pulley running at 250 r.p.m. Then, by inverse proportion:

250 : R.p.m. of small pulley = 12 : 20

By the rule of "means and extremes" we get:

12 × R.p.m. of small pulley = 20 × 250

12 × R.p.m. of small pulley = 5,000

R.p.m. of small pulley = 5,000 ÷ 12 = 416+

In working problems of this type many engineers find it easier to discard the formal statement of proportion and reason the problem out about as follows: The large pulley is $\frac{20}{12}$ as large as the small one, so the small one must turn $\frac{20}{12}$ times as fast. Hence the speed of the small pulley must be $\frac{20}{12} \times 250 = 416+$ r.p.m.

The same law of inverse proportion applies to meshing gears, using number of teeth instead of diameter.

[1] See article "How Many Decimal Places," in Jan. 23, 1923, issue of *Power* for method of telling how many places are worth while.

Axial-Flow Ljungstrom Turbine

The rotor is built up of a number of disks and annular rings. A novel scheme, including one row of moving blades fastened to the tips of an inner row, reduces the cylinder length. This combined impulse and reaction type unit forms part of a 70-ton passenger locomotive that has been in regular service since March, 1922; 1,800 hp. is developed at 9,200 r.p.m.

UNLIKE the radial-flow turbine, also designed by Frederic Ljungstrom, this is an axial-flow type, as described in the *Zeitschrift Des Vereines Deutscher Ingenieure* of Nov. 18, 1922, containing a two-row Curtis impulse stage, followed by reaction stages. In adapting the turbine to locomotive practice, no attempt has been made to approach the simplicity of the non-condensing engine; instead, refinements of modern design are relied upon for successful competition with reciprocating locomotives. A high-speed turbine, an air-cooled condenser, air preheater and forced oil lubrication for all journals are among the innovations. At the same time, the fact that the turbine and gearing are completely inclosed, is expected to result in less wear and replacement than of an equivalent piston locomotive.

Steam at 280-lb. gage is supplied by means of a flexible U-shaped pipe bend from the boiler unit, coupled ahead of the turbine-driven condenser car. Steam of 60 lb. gage for condensate heating is extracted at the impulse stage exhaust.

Owing to the high rotational stress the Curtis stage consists of two disks, centralized by plug and recess fits, instead of the usual single disk carrying two rows of blades. The impulse buckets are attached by means of bulb shanks forced into special slots in the wheel rim, similar to the De Laval construction. Reaction blades are welded into the foundation or holding rings. These holding rings are dovetailed and clamped between the annular rings of which the reaction rotor is composed. A detail of this appears at the upper right-hand corner of Fig. 1.

In order to obtain as short a cylinder or wheel casing as possible, the steam flow at the last stage is reversed in direction, so as to exhaust into a chamber surrounding the rotor. Fig. 1 indicates this construction, in which the last row of buckets is attached to the tips of an inner row. Fig. 2 shows details of fastening to accomplish this. Dovetail blade shanks permit removel of the outer row alone if desired.

Hollow Journals Act as Nuts Which Are Also Flexibly Coupled to Pinions

The Curtis disks and low-pressure annular rings are held together by two long hollow nuts, one at each end of the rotor. These are locked in place on the rotor shaft by auxiliary internal hex nuts as shown in Fig. 1. The main hollow nuts also form journals for the rotor, and are attached to flexible disks at each end, which are in turn attached to hollow shafts for driving the pinions. These drive shafts pass through larger sleeves on which the pinions are mounted, the connections being at the extreme ends, also utilizing flexible disks. The advantage of a comparatively long connection is thus obtained, made necessary from the gear-casing construction, which maintains rigid alignment between the driving pinion and driven gear shaft and flexible alignment to the turbine rotor.

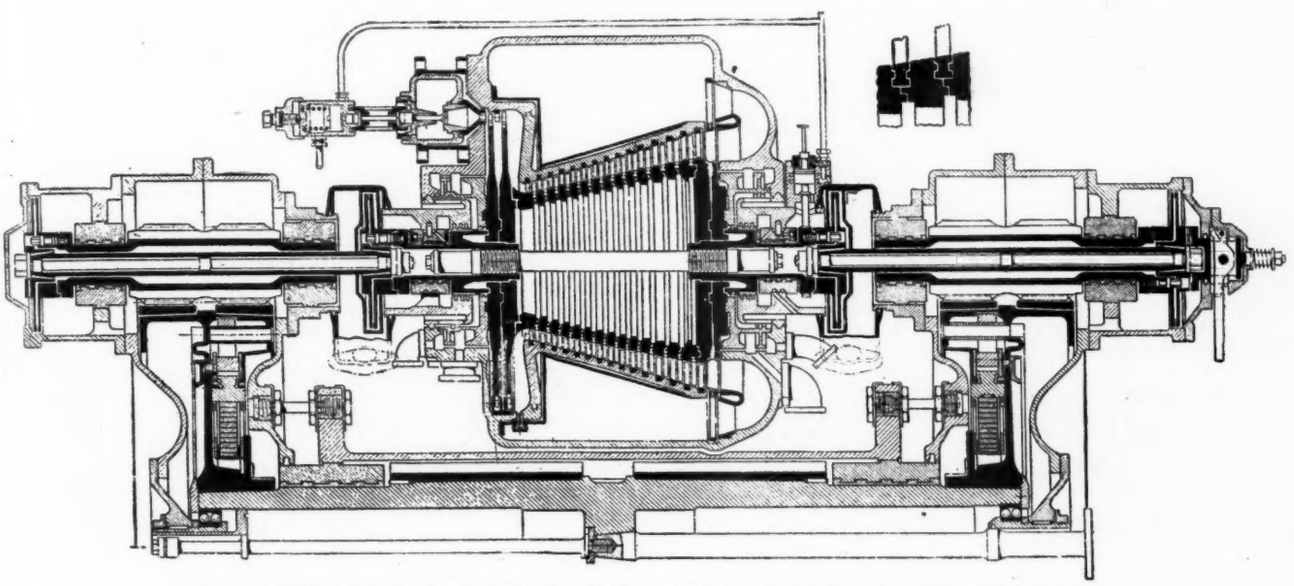


FIG. 1—BUILT-UP ROTOR FLEXIBLY CONNECTED TO DRIVING PINION AT EACH END

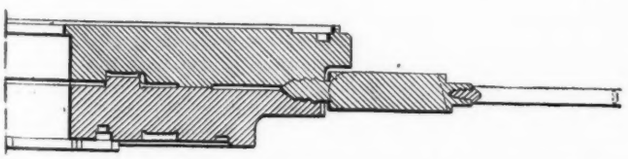


FIG. 2—FASTENING FOR SUPERIMPOSED ROW OF BLADES

The helical pinions are attached by peculiarly shaped springs to their supporting sleeves or hollow shafts. Teeth are cut at an angle of less than 45 deg. and measure approximately 0.90 in. from pitch circle to root and 0.39 in. from pitch to tip. They are thus heavily undercut for the purpose of increased tooth flexibility. Since the turbine runs in one direction only, reversing gears are provided. These are operated by oil under pressure. The construction is such that shifting must be done while the turbine is at rest. The entire gear casing is tightly inclosed.

The turbine is controlled by five oil-operated nozzles, together with an emergency governor to shut off the steam supply in the event of overspeed. An auxiliary governor cuts the oil off the gear-shifting device while the gears are revolving, so that shifting must be done with the machine at rest.

The countershaft driven by the gear turns the driving wheels by means of cranks and parallel rods. Since the crank arms are mounted on the ends of the shaft outside of the locomotive side frame, it is possible to inclose the entire

transmission in an oil- and dust-tight casing. For the first time in locomotive practice a forced-circulation oiling system has been applied. Consequently, the oil consumption is low. A large oil reservoir is provided as well as an air-cooled device for dissipating heat from the oil.

No condenser circulating water is required, as the cooling medium is aid with no evaporative cooling effect. Naturally, this necessitates the use of a huge volume of air and very large cooling surfaces.

The turbine exhaust discharges directly into the condenser shell, which is half filled with water. This water is used for feeding the boiler and is also sufficiently great in volume to condense a large quantity of steam and to maintain a fair vacuum during continuous overload. The condensed steam mixes with the water and raises its temperature. To insure ample contact surface, the water is raised by a vertical pump into a perforated header from which it

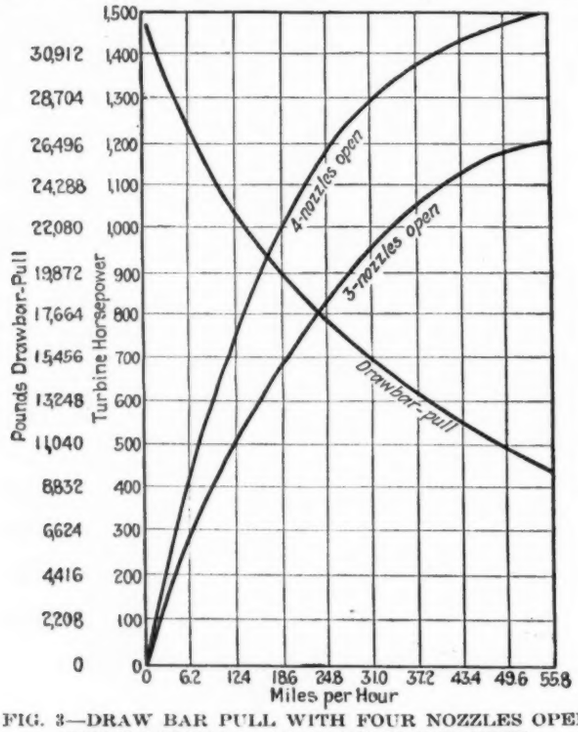


FIG. 3—DRAW BAR PULL WITH FOUR NOZZLES OPEN EQUALS 26,400 LB. AT 6.8 MILES PER HOUR

falls by gravity in the form of rain back into the bottom of the condenser shell. The remaining steam is condensed by contact with the cooling element which dissipates the heat by means of an air circulation.

The turbine locomotive was built by the Aktiebolaget Ljungstroms Angturbin at Lidingo, near Stockholm, Sweden. It was placed in service during March, 1922, on the same run with standard four-cylinder locomotives. In practical operation the coal consumption proved to be only about one-half of that required by the latter piston type. The 35 per cent gain in evaporation and the reduction in steam consumption to about 60 per cent give promise of approximately the same performance in regular practice.

The turbine locomotive, like all new developments, has not found favor with the practical railroad man, as he does not regard it as a locomotive but as a complicated machine on wheels. Only specially trained crews can be used for running the locomotive. More supervision and less manual labor are required to operate it. This is a sharp competitor of the electric locomotive, requires no water, is almost equal in durability with the latter and is considered superior in flexibility, fuel economy and amortization of investment.

The relation between the locomotive speed and drawbar pull is illustrated by the curve in Fig. 3. The large drawbar pull of 26,400 lb. at 6.87 miles per hour, which is nearly one-quarter of the weight on drivers, is notable. As the turning moment is perfectly uniform, the tractive effort can be applied more efficiently than with the piston locomotive.

In starting, the turbine efficiency is very low, because the steam passes through the high-pressure velocity stage without loss in velocity and enters the reaction stages at about twice the normal pressure, which doubles the turning moment. The velocity stage is even more unfavorably affected during acceleration, but this condition rapidly diminishes as the locomotive gathers speed, so that this does not seriously affect the over-all economy.

Furnace Design for Iowa Coal*

By John Drabelle
Chief Engineer, Iowa Railway and Light Company

To understand better the factors governing furnace design and construction for Iowa fuel, some attention should be given to the various constituents of several kinds of coal; namely, Iowa, Illinois and Virginia. It will be noticed from the accompanying table that the volatile content of Iowa coal is more than double that of Virginia and about 2 per cent higher than that of Illinois. The figures given are the average of many analyses.

PROXIMATE ANALYSES OF VARIOUS COALS

	Iowa	Illinois	Virginia
Moisture	12.0	16.0	2.0
Volatile	36.0	34.0	16.0
Fixed Carbon	35.0	39.0	76.0
Ash	17.0	11.0	6.0
B.t.u	10,244 to 8,900	12,100 to 10,400	14,636 to 13,995

It will be evident that a furnace designed to burn Iowa fuel will not handle successfully Virginia or Kentucky coals, which are quite similar, but will with a fair degree of success burn Illinois coal. This was demonstrated thoroughly during the recent coal strike, when many of the central stations in Iowa attempted to operate on the Eastern coals having a high fixed carbon content and comparatively low volatility.

When stokers were first installed in Iowa, the general practice in stoker-arch and furnace arrangement followed generally the work that had been done previously in Illinois. In the Cedar Rapids plant of the Iowa Railway & Light Co., which was one of the early stoker plants of the state, relatively small stokers were first used. The arch was of the sprung type, built up of wedge-shaped brick. In the center of the furnace it cleared the grate approximately 24 in. and on the sides about 10 in. The boilers were set approximately 8 ft. from the floor to the lower row of tubes, giving a limited combustion volume. Ignition rates were low and uncertain, and consequently the efficiencies were low. With the development of the flat-tile, suspension type of arch the early installations consisted of flat arches parallel to the grate, with headroom not exceeding 16 to 18 in. The only virtue of this particular design was that it was somewhat cheaper to construct than the old sprung arch and considerably cheaper to maintain.

With the coming of the war and the consequent restriction on materials, increasing loads upon central stations made it imperative that they get more out of their boiler plants than they had heretofore. This started considerable investigation with the result that some of us timidly raised the arches at the rear end of the stoker a small amount. Immediately boiler ratings went up and the evaporation improved. As these various arches wore out in service, the angle between the arch and the grate was increased step by step until finally the rear row of arch tile was tangent to the bottom of the boiler header or drip pan.

Owing to the fact that our boiler plants were already constructed and built, it was not possible, from an economic point of view, to tear down the settings and raise the boilers, with the consequent changes in piping, boiler breeching, steelwork and alterations to the building. Other means had to be devised to increase furnace volume. A modified form of bridge wall was designed to reflect the heat from its surface forward to the feed gate of the stoker, thereby securing a high initial temperature at the point of entrance of the coal and a prompt ignition. These changes in bridge walls improved ignition and gave a certain increase in furnace value, although not enough.

*Excerpts from paper read before the Iowa Engineering Society, Des Moines, Jan. 23, 1923.

The next step was to build an ell-shaped arch, the long portion of the ell being parallel to, and as high up from, the grate as the physical dimensions of the boiler would permit. The vertical portion of the ell was extended down until it cleared the grate at the front approximately 18 in. A short horizontal run to the feed gate gave a small area of highly heated firebrick to assist in the ignition of the coal.

At the feed gate of the stoker immediately under the arch, the gases liberated are of a tarry nature and unless promptly ignited and supplied with sufficient air to complete combustion, form later in their travel through the furnace complex chemical compounds which do not readily re-ignite and burn, giving the stack a smoky appearance. To this end certain developments are now being made to introduce highly heated air at suitable pressure, velocity and volume to bring these gases the necessary oxygen to complete their combustion.

Before this arch development took place, evaporative rates of around 5 lb. of water per pound of Iowa coal and boiler ratings not exceeding 110 to 125 per cent of nominal capacity were prevalent. Today, in the modern plant, the evaporation has increased to 6 or 7 lb. of water per pound of Iowa coal and boiler capacities have been raised to 200 to 250 per cent of rating. Also, the flexibility of the boiler plant has been improved, making it possible with Iowa fuel on chain-grate stokers to handle successfully such rapidly fluctuating loads as those imposed by a street railway and interurban systems.

With these changes have come, owing to the larger volumes, lower gas velocities in the furnace, thereby reducing the amount of fine ash carried in suspension from the fuel bed and lessening trouble from slag formation on the tubes. The larger furnaces with the lower gas velocities give less blowpipe effect on the boiler tubes, thereby reducing tube maintenance, which had been no small item.

Hand in hand with all these changes came improvements in boiler baffling, elimination of dead pockets in the boilers, uniform gas velocities through the boiler, giving better heat transfer and higher boiler efficiency, tight furnace walls, suitable refractories and improved boiler-room instruments —all helping in the improvement of furnace operation.

The pioneer work of burning Iowa coal more efficiently was started by F. C. Chambers, president of the Des Moines City Railway Company and T. A. Marsh, chief engineer of the Green Engineering Company. To these two men belong much of the credit for showing a better way of handling this fuel.

Progress in Power Development

By Prof. A. G. Christie*

Increased costs of fuel and of labor have had a material effect on plant design. Emphasis is now placed on the operation of the plant as a whole rather than on prime mover or boiler alone. This has led to careful study of the heat balance of the complete plant. Such studies often develop possibilities for improvements and have a stimulating effect on the management. In new designs much thought is devoted to heat-balance studies of various schemes before a final selection is made. Minor heat losses, such as those in the generator cooling air, transformer losses, bearing losses and gland leakage, are now being recovered and utilized. Systems of operating auxiliaries to secure the lowest B.t.u. per kilowatt-hour of net station output are being developed which differ radically from former practice. In some cases house turbines are employed with motors on all auxiliaries. These, however, will probably be omitted from future stations where economizers are not used and all power for auxiliaries will be furnished from the main turbines, which will be of the multiple bleeder type. Certain of the essential auxiliaries will be equipped with synchronous motors and a duplex steam drive in reserve, that will pick up load in an emergency and will operate certain other auxiliaries with the synchronous motor acting as a generator.

Substantial progress is being made both in size and in designs of large turbo-generators. Types built under the stress of war conditions developed certain weaknesses, and as a result all the large companies both here and abroad have been redesigning and improving their machines. The newer designs are more compact and better built. The ideal turbine will provide the steam with the smoothest and most direct expanding passages free from sudden changes in cross-section or in direction, and with stationary and revolving guides or buckets whose curved surfaces offer the minimum of shock to the high-velocity steam. This ideal is being approached in recent designs. A uniform distribution of steam in the exhaust pipe and the utilization of the velocity energy leaving the blades are also attempted in some of the new units.

Multi-stage bleeding is becoming standard practice with large steam turbines. Engineers will soon demand that the builders themselves provide the turbine and bleeders and base all guarantees on the performance of the unit as a whole, resulting in better design and improved thermodynamic performance.

The characteristics and limitations of small steam turbines are becoming better known. New designs embody substantial improvement over earlier types. There is still need for further improvement in these units intended for auxiliary service. Small steam turbines have not been able to compete on the basis of economy with unaflow engines.

Tendency to Increase Pressures and Temperatures

There is a decided tendency to increase steam pressures and temperatures. Mr. Orrok ably discussed this subject in his recent paper on "The Commercial Economy of High Pressure and High Superheat in the Central Station."[1] He concludes that 1,200 to 1,500 lb. is commercial but that temperatures are limited to about 750 deg. F. until better materials can be developed for valves and piping. The Benson system now being considered in Great Britian goes to pressures in the neighborhood of 3,200 lb., but while sound theoretically has not been commercialized. Recent announcement of plants to use 550 lb. seems to indicate conservative design as far as ultimate limitations are concerned.

Boilers are now operated for varying periods at high ratings. This can be done only where the tube surfaces are free from scale and the feed water is free from foaming alkalis. Hence the feed water must be kept pure. Many stations now employ evaporated makeup. If low-priced evaporators were available in small sizes, it would be advisable to furnish distilled makeup for feed water in a great many of our small plants where only impregnated water is available.

Rising coal prices have resulted in the wider adoption of economizers, which in high-pressure plants have steel tubes. Several new problems have been presented to engineers by the adoption of these steel tubes. In the first place corrosion is very rapid and very destructive if any oxygen remains in solution in the feed water. Hence various methods and equipment have been devised to deaërate the feed water. Difficulty with corrosion of the outside of economizer tubes has been encountered where coals high in sulphur are used. A study of the dew points of sulphur compounds may reveal the cause of this difficulty.

In plant economy the B.t.u. per kilowatt-hour developed has been steadily reduced and will be further lowered when some of the newer ideas on heat balance have been fully developed.

Proposed hydro-electric developments in New Zealand, according to Commerce Reports, involve a total expenditure of some $60,000,000. This is to be spread over a period of ten years, reaching a maximum of about $10,000,000 in 1925. The financial condition of the country has made it necessary to postpone for a couple of years the beginning of the main work at Lake Waikaremoana, and to hold over a number of the smaller developments in the South Island until power boards have been formed to handle the question of distribution. Everything will be pushed ahead rapidly in order to make the supply of electricity as general as possible up to the capacity of the head work at each site.

*Retiring chairman Power Division, A.S.M.E.

[1] See *Power*, Oct. 31, 1922.

News in the Field of Power

May Standardize Symbols

A.E.S.C. To Consider Simplifying Abbreviations and Symbols Used in Engineering Formulas

NO LONGER will the engineer have to puzzle over the meaning of abbreviations and symbols used in equations and formulas, if anything comes of a conference between the American Engineering Standards Committee and representatives of the leading engineering societies.

The need for the standardization of abbreviations is emphasized by the confusion resulting from the variety of symbols and the number of meanings of one symbol. The expression "pounds per square inch," for instance, may be represented by at least a half dozen abbreviations. Some English journals use "h.p." for "high potential," whereas in the United States it is generally used to mean "horsepower." The mark (") may mean inches, seconds or a quotation.

Great confusion necessarily results from the use of three or more symbols for the same thing. The elimination of these ambiguities will be a great help to both student and engineer. The standardization of American engineering symbols and abbreviations should also eliminate the difficulty experienced by foreign engineers in correctly translating English articles into their own language.

The conference, which will determine whether the standardization of engineering abbreviations and symbols should be undertaken, and if so, to what extent, has been called by the A.E.S.C. in response to requests received from the A.I.E.E., the American Society of Mechanical Engineers, and the Association of Edison Illuminating Companies. It will meet at the Engineering Societies Building, New York City, at 10 a.m. on Feb. 13. Any organization desiring to be represented that has not received an invitation is requested to communicate with the American Engineering Standards Committee, 29 W. 39th St., New York, N. Y.

To Build Tidal Power Plant in France

The French Government has passed a bill for the construction of an experimental tidal electric power station at Aber-Vrac'h, according to information contained in a recent issue of *The Engineer* (London). This site was selected because the shape of the estuary was particularly suited for the purpose and because the difference in level between high and low sides was large.

It is planned to construct a dam 492 ft. long across the estuary, with its top about 13 ft. above extreme high water. A lock will permit the passing of fishing boats. The generating machinery will be placed in a caisson in the center of the dam and will contain two turbines capable of developing 75 to 1,200 hp. each, depending upon the difference in level on the up- and down-stream sides of the dam. The turbines will operate on both incoming and outgoing tides. To furnish power during the period when the turbines can give no power at all, it is proposed to build a dam above tide level on the River Diourin.

It is estimated that a maximum of 4,800 hp. will be furnished by the installation, and that the regular production will be at the rate of 1,600 hp.

Wages Still Double Those of Pre-War Times

While there are only 16 per cent more employees of water, light and power companies in New York State than there were in 1914, these are now being paid two and one-third times as much as in pre-war days, according to the latest New York State Industrial Bulletin. In the factories of the state, workers are being paid just twice the amount they received in 1914, while for the country as a whole the average retail price of food stands at 66 per cent and the cost of living at 40 per cent greater than in 1914.

Instrument Designer Wanted for Civil Service

A $3,000 position for a mechanical engineer experienced in the design of precision instruments will be filled from a Civil Service examination, for which the receipt of applications is to close Feb. 20. Competitors will not be required to report for examination at any place, however, but will be rated on their education, training and experience.

Applicants must be between 25 and 45 years of age, and must show that they have been graduated in engineering preferably mechanical, from a recognized college or university, and that in addition they have had at least three years' experience as successful dsigners of precision instruments. Experience in this field may be substituted for the last two years of the college course, if necessary. Scientific courses other than engineering will be accepted for not more than three-fourths time value. Applicants should apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C., or to the secretary of the United States Civil Service Board in any city.

Recommend Coal Storage

Fact-Finders Delay Public Hearings Until They Have Gathered More Facts

IN discussing the coal situation after the New York agreement, Chairman Hammond of the Coal Commission said that the Commission believes that the railroads could contribute greatly to the public good by storing the maximum possible proportion of their requirements during the period of open-top car surplus. From the trend of his remarks it is apparent that the Commission has little patience with the practice of the railroads in commandeering coal. Apparently, the Commission has in mind a recommendation that no coal be commandeered without permission of the Interstate Commerce Commission. His remarks also indicate that the Commission is attaching great importance to the whole matter of shortage, including certain limited storage at the mine which will give greater flexibility to operation.

Another remedial proposition to which the Commission attaches importance was revealed to be that of special inducements to encourage tidewater movement during the period of car plenitude.

The Commission had planned to begin public hearings during the latter part of January. It has been found, however, in the informal conference, that much more progress is made when the Commission has facts at hand with which to check the statements by those appearing. For that reason public hearings will be delayed until the fact-finding activities have progressed further.

Plans for Future Work

Among the things that the Commission has in mind for early study is the matter of absenteeism, the check-off and the relative advantages and disadvantages of unionized and open-shop operation of mines. More attention now is to be turned to the anthracite situation.

At the New York meeting the operators and mine workers, in agreeing to maintain the status quo for one year, did exactly what the Commission requested them to do, although it has been revealed since that the Commission was prepared to advocate an extension of the existing agreement for two years. Since only a one-year agreement has been reached, the Commission will try to speed up its work so as to have its conclusions in final form at an earlier date than had been anticipated, thereby making its recommendations available in time for public opinion to crystallize and still give Congress an opportunity to act before April 1, 1924.

Baruch Favors Ford Offer

Former Chairman of War Industries Board Bases Opinion on Fertilizer and Preparedness Features

ACCEPTANCE of Henry Ford's offer for Muscle Shoals, provided no better offer is available and provided that he actually produces nitrogen for fertilizer at the rate of 40,000 tons a year, is recommended in a special report made to the American Farm Bureau Federation by Bernard M. Baruch, war-time chairman of the War Industries Board.

All doubt in regard to Mr. Ford's personal liability should be removed, says Mr. Baruch in his report. He adds:

"The most important thing that ought to be clarified is the following: That Mr. Ford undertakes to make 40,000 tons of fixed nitrogen per year, and that if he does not make it the property is to revert to the Government. After all, it is the fixing of the nitrogen that is the crux of the whole contract. I am quite sure that the contract means to cover this point, but it should be made clear."

Along with Mr. Baruch's letter, there was made public the engineering report that guided his conclusions. The best utilization of the government's vast investment at Muscle Shoals, said Leland L. Summers, author of the report, would come from the acquirement of the plant by a group of industries able to develop an industrial center which would absorb the power and convert the raw materials to the best advantage of the country in war-time. In closing, the engineer said:

"Whoever may be handed Muscle Shoals will receive from the government a vast potential possibility, a tool which may effect the economic rearrangement of the particular industry to which it is applied. The Ford offer, ridiculous as it is as to price paid for this valuable asset, promises the greatest financial return to the government and the most efficient war measure of any available plan."

New York Mayors Submit Water-Power Report

Recommendations for the repeal of the New York State Water-Power Act, also known as the Robinson law, and for the adoption of legislation calling for state development of hydro-electric energy, are contained in a report submitted to the Legislature on Jan. 26 by the water-power committee of the State Conference of Mayors.

In its report, the conference of Mayors favors the passage of a law similar to the Graves-McGinnies bill, which passed the Senate in 1919 but failed of passage in the Assembly. This bill would give the State Conservation Commission the power to acquire and to develop water powers within the state and along its boundaries; to generate and to sell or lease power to municipalities, individuals or corporations, giving preference to municipalities.

"The price to be charged by the Commission for electrical power," says the report, "must be sufficient to pay for the land and water rights for the development and operation of power plants, for power distribution and for all other overhead expenses, including depreciation, the principal and interest on bonds and also for repayment to the state of the capital furnished and other expenses incurred by it through the Commission. In other words, the rates must be sufficient to make the undertaking absolutely self-supporting."

Nothing is said, however, about methods of financing state water-power projects. The Democratic party leaders have virtually committed themselves to a scheme to bond the state this year for $15,000,000 for further park development, and as but one bonding issue can be submitted to the people at one general election there seems to be little chance that a bonding bill for hydro-electric development will be presented this year.

Upon completion by the Alabama Power Co. of a new substation at Leeds and a 50-mile, 110,000-volt transmission line, the manufacturing plants of the Birmingham district will be supplied with power from Mitchell Dam, Lock 12, Gorgas, Gadsden and Jackson Shoals. Birmingham will thus become the center of an electric power loop, with 350,000 hp. available.

Water-Power Projects

Twelve applications for permits or licenses were filed with the Federal Power Commission during the two weeks period ending Jan. 20, making a total of 372 received to that date.

The City of Louisville has applied for a preliminary permit to develop power on the Green River, in Edmonson County, Ky., at a point one mile above the Mammoth Cave. The project is to be operated in conjunction with the proposed development on the Ohio River at the Falls of Louisville, to supplement the power supply when the Ohio River dam is flooded out.

The City of Louisville has also applied for a permit to construct, for power purposes, a high dam in the Cumberland River, at a point 2½ miles above Burnside, in Bulaski Co., Ky. This project would also be operated in conjunction with the Ohio River project.

D. L. and W. L. Carver have applied for a permit for a 200-ft. dam to store 200,000 acre-feet on Bear River in Routt Co., Colo., at a point about 15 miles above Steamboat Springs. A pipe line two miles long will lead to a power house of 10,000 hp. capacity.

The Southern California Edison Co. has applied for a license for its constructed plant on the Tule River, in Tulare County, Calif., known as Plant No. 4.

W. **Neuman** and **Dave Hirstel** have applied for a permit involving the construction of a reservoir in the San Benito River, in Hernandez Valley, San Benito County, Calif., and a canal and 4-mile tunnel to divert water into the watershed of Panoche Creek, where a power house of about 10,000 hp. will be built. The water will then be used for irrigation in San Benito County.

The City of Los Angeles has applied for a permit to divert Leevining, Rush, Walker and Parker Creeks from the Mono Lake watershed through a tunnel and conduit into the Owens River drainage. The water will de-

Shell Cooler Explodes in Detroit

Accumulated Pressure and Defective Weld in Cooler Combine to Cause Explosion.

A SHELL cooler in the North Grand River plant of the Absopure Ice Company, Detroit, exploded at 7:45 p.m. on Jan. 12, damaging the building and equipment to an extent estimated at $15,000. As the plant was operated only during the day in the winter season, it was shut down at the time of the explosion and no one was in the building; hence no personal injuries were sustained.

The plan was of 75 tons capacity and contained two horizontal double-acting compressors belted to electric motors. The cooler that exploded was 42 in. diameter by 10 ft. 8 in. long and made of ⅜-in. plate. The heads were ⅝ in. flat and were supported by some 100 two-inch tubes. It had been in service about nine years, and all its seams had been welded by the acetylene process at the time of construction.

The direct cause of the explosion was evidently that the cooler had been practically filled with ammonia, the valves closed and the tank allowed to stand in this condition for twenty-four hours, allowing the temperature to rise enough to cause overpressure, the cooler being piped in such a manner that relief was not provided when the cooler was cut off from the system.

That the overpressure did not necessarily have to be very high to cause the explosion was apparent from a subsequent examination of the cooler. The longitudinal joint had evidently been V'ed or scarfed, and the welding showed that a large portion of the seam had not been filled with the welding material and that in places the welding was not over ⅛ in. thick. Hence, the longitudinal seam opened up the whole length of the tank, tearing the heads loose from the shell, throwing the cooler out of its setting, wrecking the piping and blowing out the roof for the greater part of its length.

The compressor equipment was not damaged, although a heavy firedoor leading from the compressor room to the tankroom was destroyed and the plate glass in the compressor room, which fronts the street, was blown out.

velop an additional 40,000 hp. in Owens Gorge, it is estimated. It is proposed also to use this additional water in irrigating 50,000 acres in the vicinity of Owens Lake, at a cost of about $8,000,000. This project is in direct conflict with a proposed project for which an application has been filed by the Nevada California Power Co., which is operating plants on Leevining and Rush Creeks and proposes to develop additional projects to utilize all the available head above Mono Lake.

New Publications

The Twelve-Hour Shift in Industry.—By the Committee on Work Periods in Continuous Industry of the Federated American Engineering Societies. Published by E. P. Dutton & Co., New York, 1922. Cloth; 6x8 in.; 302 pages; 13 tables. Price, $3.50.

Our industrial system has become so large and its many ramifications so involved that it is difficult to obtain a true perspective of any one phase, let alone industry as a whole. There is no more important problem in industry than that involving labor, and as this book represents the results of two years' study fostered by the Federated American Engineering Societies, on hours of employment, it is of particular interest. In 1920 a committee composed of eight leading members of the engineering profession began an organized study of the twelve-hour shift in the operation of continuous process industries. This investigation involved four groups of industries: Heat-process industries, such as iron and steel, cement, brick, etc.; chemical industries; heavy-equipment industries, such as paper, flour, mines, etc.; service industries, such as power, gas, railroads, etc., covering in all 43 classes. The study not only involved the number of employees working on the different shifts, but also dealt with the practicability of making the change from a twelve-hour to an eight-hour shift, the most economical method of changing and its economical effect upon industry. One of the conclusions of the committee is that "there is a natural divergence of opinion as to the advantages and disadvantages of the three-shift operation, but the weight of the evidence and the most positive statements are in its favor." For those who are in any way interested in the labor problem this book should prove to be a valuable asset.

Obituary

John B. McGowan, operating superintendent of the Cunard Building, New York City died on Jan. 31, at the age of fifty-one. He was an active member of Brooklyn Association No. 8, N.A.S.E., and was chairman of the Power Plant Course Committee of that organization. Mr. McGowan was a member of the American Society of Mechanical Engineers, the New York Building Superintendents' Association and the Woodmen of America. He is survived by his widow, two sons and a sister. The interment was at Old Calvary Cemetery on Feb. 5.

Personal Mention

W. N. Walmsley has resigned from the general managership of the Alabama Power Co. on account of ill health. After a vacation in South America, however, he will return as vice-president of the company. Eugene A. Yates, of New York City, who succeeds Mr. Walmsley as general manager, was chief engineer in the construction of Lock 12, on the Warrior River, and has been connected with the company as a consulting engineer since that time.

Coming Conventions

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Winter meeting at New York City, Feb. 12.

American Institute of Electrical Engineers, 29 West 39th St., New York City. Mid-winter convention at New York City, Feb. 14-17.

Universal Exposition of Inventions and Patents, Grand Central Palace, New York City, Feb. 17-22.

American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 19-21.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, Apr. 16-18; spring meeting at Montreal, Canada, May 28-31.

American Association of Engineers, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Society Affairs

Metropolitan Section, A.S.M.E., will consider "Coal Handling for Power Stations" at its meeting on Feb. 13.

Franklin Union, Berkeley and Appleton Sts., Boston, will give an illustrated lecture on Feb. 6, on "Electric Boilers."

Baltimore Section, A.S.M.E., will meet Feb. 14 at the Engineers Club. Motion pictures of plant processes of the Commonwealth Steel Co. will be shown.

Cincinnati Section, A.S.M.E., will hold a joint meeting Feb. 8 with the student branch, University of Cincinnati, at the engineering college building. **Louis W. Arny,** of the Leather Belting Exchange, will speak on "Leather Belting."

Boston Section, A.S.M.E., will hold a joint meeting on Feb. 8 with the student branch at Massachusetts Institute of Technology, Cambridge. Mr. Ballard, of the Oil Equipment Co., will speak on "Oil Fuel." President S. W. Stratton of M.I.T. will speak, after which the M.I.T. Musical Clubs will entertain.

Business Notes

The London Steam Turbine Co. has elected Carlos De Leon as president; Walter H. Damon, vice-president; Charles A. Sleicher, treasurer and chairman of the Board of Directors; S. S. Waters, assistant treasurer, and George W. Pentheny, chief engineer. Ivan S. Forde, sales manager, was elected to the Board of Directors.

The Swartwout Co., Cleveland, Ohio, was recently formed for the manufacture of Swartwout steam specialties, formerly made by the Ohio Body & Blower Co. The latter company will now make automobile bodies exclusively, while the Swartwout Co. will continue the manufacture of ventilators, core ovens, enameling ovens, metal buildings and steam specialties, including exhaust heads, steam and oil separators, steam traps and feedwater heaters. The officers are: D. K. Swartwout, president; W. M. Pattison, formerly president of the Pattison Supply Co., and D. K. Swartwout, Jr., vice-presidents, and W. E. Clement, secretary and treasurer. Mr. Clement was formerly secretary of the Ohio Body & Blower Co.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Jan. 22 1923	Jan. 29 1923
Pool 1,	New York	$5.50–6.00	$5.25–5.75
Smokeless,	Columbus	6.50–6.75	6.75–7.75
Clearfield,	Boston	4.50–5.00	4.00–4.75
Somerset,	Boston	4.75–5.25	4.25–4.85
Kanawha,	Columbus	3.25–3.50	3.15–3.40
Hocking,	Columbus	2.75–3.00	2.65–3.00
Pittsburgh No. 8	Cleveland	3.50–3.75	3.25–5.50
Franklin, Ill.,	Chicago	3.75–4.00	3.75–4.00
Central, Ill.,	Chicago	2.75–3.00	2.75–3.00
Ind 4th Vein,	Chicago	3.50–3.75	3.50–3.75
West Ky.,	Louisville	2.50–2.75	2.25–2.75
S. E. Ky.,	Louisville	3.00–3.25	3.00–3.25
Big Seam,	Birmingham	2.25–2.50	2.25–2.50

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—Feb. 1, Port Arthur light oil, 22@25 deg. Baumé, 4¾c. per gal.; 30@35 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—Jan. 13, for 24@26 deg. Baumé, $1 per bbl.; 32@36 deg., 3c. per gal. in tank car.

Philadelphia—Jan. 29, 26@28 deg. Baumé, Oklahoma, $1@$1.05 per bbl.; 30@34 deg., Oklahoma (group 3), 3@3¼c. per gal.; 16@20 deg. Seaboard, $1.30@$1.40 per bbl.

St. Louis—Jan. 29, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95; 28@30 deg., $2; 32@36 deg., $2.25; 36@40 deg., $2.45.

Pittsburgh—Jan. 9, f.o.b., refinery, Penn., 36@40 deg., 5¼@5¾c. per gal.; Kentucky, 26@30 deg., 4c.; Gas oil, 32@36 deg., 2¼@2¾c.; 36@38 deg., 2½@3c.; 38@40 deg., 90c.@$1.05 per bbl.

Dallas—Jan. 27, 26@30 deg., $1.33 per bbl.

New Plant Construction

PROPOSED WORK

Calif., Santa Rosa — The Santa Rosa Hotel Corp., c/o Dunnhurst & Martin, Insurance Exchange Bldg., San Francisco, is having plans prepared for the construction of a 6 story, hotel and apartment building. Estimated cost $500,000. W. O. Lewis, 1207 High St., Alameda, Archt. Ellery, Frost & Patton, Merchants' Natl. Bank Bldg., Engrs. Noted Jan. 16.

Calif., Caruthers—Caruthers Union High School District, J. C. Gallagher, Clk., will receive bids until Feb. 12 for a 5 hp., 3-phase electric motor, direct connected to 3 in. pump with switchboard and appliances.

Calif., Lodi—The city council will receive bids until Feb. 8 for the construction of an activated sludge plant, pump house, concrete foundations, etc., in connection with sewage disposal plant. Estimated cost $75,000. L. F. Barzellotti, City Engr. C. F. Smith, Nottingham St., Berkeley, Consult. Engr.

Calif., Los Angeles—Hart Bros., c/o Rosslyn Hotel, 453 South Main St., will soon receive bids for the construction of a 12 story hotel on 5th and Main Sts. J. and D. Parkinson, Title Insurance Bldg., Archts. Equipment detail not reported.

Calif., Oakdale — The Oakdale & South San Joaquin Irrigation Districts plans election to vote $3,750,000 bonds to finance construction of Melones Reservoir and power house project.

Calif., Oakland—The State Dept. of Pub. Wks., Div. of Architecture, will receive bids until Feb. 13 for the construction of women's shop building, employees' cottage, recreation building and power house, at 3601 Telegraph Ave. G. B. McDougall, Forum Bldg., Sacramento, Archt. Noted Aug. 1, 1922.

Calif., Palo Alto—The C. H. Steere Mfg. Co. is in the market for 2 power belt sanders and 1 automatic cut-off saw.

Calif., San Francisco—The city and county are having plans prepared for the construction of a group of buildings for Relief Home. Estimated cost $2,000,000. J. Reid, Jr., First Nat'l Bank Bldg., Archt. Equipment detail not reported.

Calif., Tiburon—The Bureau of Yards and Docks, L. E. Gregory, Chf., Washington, D. C., will receive bids until February 7, for water supply system, here, including c.i. water mains, together with all fittings, valves, hydrants, and connections to existing pipes, meter and pump.

Calif., Turlock—E. T. & W. P. Eaton, c/o Turlock Chamber of Commerce, plans the construction of an ice plant on North Center St. Estimated cost $30,000.

Col., Denver—Fisher & Fisher, Archts., U. S. Nat'l Bank Bldg., will receive bids until March 1, for the construction of a hospital, consisting of administration building, medical school, nurses' home and outside patients building on 8th St. and Colorado Blvd., for the State of Colorado. C. W. Mills, Chn. Bldg. Comn. General contract will include heating, electrical installation, etc. Estimated cost $1,000,000.

Col., Fort Morgan—The city council plans the installation of two 1,000 kw. Allis-Chalmers turbines, 2 Badenhauers boilers and Elliott condensers, for proposed light and power plant, 2,000 kw. capacity. Estimated cost $165,000. Wood & Weber, 507 Tramway Bldg., Denver, Engrs.

Fla., Jacksonville—H. W. Dexter, Box 665, is in the market for 2 stage air compressor, locomotive type, for use on dredge boat for air tools; 1 yd. steam shovel, crawler or caterpillar type; 5 or 6 ton steam tandem type road roller; 100 or 125 hp. open type (Cochrane preferred) water heater.

Ga., Newton—The Baker County Powder Co. plans to rebuild its power plant, recently destroyed by flood. Estimated cost $75,000. Owner is in the market for machinery and equipment.

Ga., Atlanta—The Glen Estate, c/o W. B. Wood, Archt. and Engr., 816 Commonwealth Ave., N. W., Wash., D. C., will soon award the contract for a 10 story office building, here. Estimated cost $1,000,000. Equipment detail not reported.

Ill., Carlyle—The city, J. A. Means, Clk., will receive bids until February 19 for the construction of a complete filtration plant, including 2 new centrifugal pumps with motors, transformers, connections, etc., filter appurtenances, mixing chamber, sedimentation basin, etc. Dawson & Walraven, Springfield, Engrs.

Ill., Chicago—Hetzel & Co., 1739 Larrabee St., is having plans prepared for the construction of a 1 and 2 story, 70 x 122 ft. power plant. Estimated cost $60,000. D. I. Davis & Associates, 327 South La Salle St., Archts.

Ill., Chicago—A. Johnson, c/o J. Nyden, Archt., 190 North State St., is having plans prepared for the construction of a 12 story hotel on Pine Grove Ave. and Diversey Blvd. Estimated cost $2,000,000.

Ill., Chicago—The Palmer House Hotel Co., c/o Holabird & Roche, Archts., 104 South Michigan St., is having plans prepared for the construction of a 23 story, 248 x 254 ft. hotel, including steam heating system, on Monroe St. Estimated cost $12,000,000.

Ill., Chicago—Peters & Horwitz, 10 South La Salle St., plan the construction of a 240 x 490 ft. theatre, store and office building, including steam heating system, on Robey St. and Belle Plaine Ave. Estimated cost $1,200,000. Architect's name withheld.

Ill., South Chicago (Chicago P. O.)—E. E. Hall, Archt., 123 West Madison St., is preparing plans and will soon receive bids for a 4 and 5 story, 125 x 149 ft. hospital, including steam heating system, on 11th and Perry Sts., for the South End Hospital Assn., 11212 South Michigan Ave., Chicago. Noted June 27, 1922.

Ill., Kewanee—The city is having plans prepared for the construction of a new municipal electric light plant and equipment. Estimated cost $125,000. Burns & McDonnell, 402 Interstate Bldg., Kansas City, Mo., Engrs.

Ind., East Chicago—The Pressed Steel Mfg. Co., 20 West Jackson Blvd., Chicago, is having plans prepared for the construction of a 2 story factory and office building here, including steam heating system. Estimated cost $750,000. F. D. Chase, Inc., 645 North Michigan St., Chicago, Archts.

Ind., Indianapolis—The Goldsmith Iron & Supply Co., 403 South Illinois St., is in the market for 6 in. 3 stage centrifugal pump, 250 lb. head pressure.

Ia., Des Moines—The Des Moines General Hospital is having plans prepared for the construction of first unit of a hospital on East 12th and Des Moines Sts. Estimated cost $350,000. Berlin, Swern & Randall, 19 South La Salle St., Chicago, Ill., Archts. Equipment detail not reported.

Kan., Eldorado—The Evans Thwing Refining Co., 624 Finance Bldg., Kansas City, Mo., is having plans prepared for the construction of a refinery. Estimated cost $500,000. New machinery and equipment will be purchased. Private plans.

Md., Baltimore—The City Council, H. G. Perring, Supt. Engr., is having plans prepared for the construction of a 3 story, 60 x 227 ft., school building, including steam heating plant, on Nevada and First Sts., at Westport. Estimated cost $600,000. B. Frank, 328 North Charles St., Archt. H. Massart, 328 North Charles St., Engr.

Mass., Westfield—L. Saffer, 92 Franklin St., plans the installation of a 125-250 hp. heating and power plant to supply several factory buildings.

Mich., Detroit—J. P. Jogerst, Archt., 1921 Ford Bldg., plans the construction of a 12 story, 90 x 95 ft., hotel, including steam heating boiler and equipment. Estimated cost $800,000.

Miss., Columbus—The State Bond Improvement Comn., Box 636, Jackson, will receive bids until Feb. 24 (change of date) for the construction of a power plant at the Mississippi State College, here, including furnishing on board cars, 2 cross drum type water tube boilers about 250 hp. each; 3 hand fitted stokers with hopper fronts for 250 hp. boilers; 2 sets rotating soot boilers and 1 set hollow stay bolt type soot blowers for horizontally baffled marine type boilers; 1 open type feed water heater; 1 outside packed plunger ram pattern boilers feed pump; 1 steel breeching for boilers; 6 x 125 ft. radial chimney, rebuilding boiler house, etc.; erecting 3 new boilers and moving one 250 hp. boiler and installing stokers, etc.

Miss., Gulfport—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., will receive bids until Feb. 21, for the construction of a U. S. Veterans Hospital, here; also for refrigerating and ice making equipment, including motor driven compressors, condensers, liquid receiver, motor driven brine pumps, filters, brine agitator, and water agitating system by compressed air, etc., and equipment for storage and handling of goods. Spec. 4774 and 4780. Noted Sept. 19.

Mo., Holden—The city plans extensive improvements to waterworks system, including rebuilding of present dam, increasing water supply and construction of modern water filtration plant, new pumping station, additional water mains and new elevated tank. Benham Engr. Co., 512 Gumbel Bldg., Kansas City, Consult. Engrs.

Mo., Kansas City — Advance Electric & Mfg. Co. is in the market for a 10 hp. motor.

Mo., Kansas City—The Lumberman Bldg. Co., 412 Scarrett Blvd., is having plans prepared and will receive bids until Feb. 15 for the construction of a 10 story, 102 x 115 ft. office and store building on 24th and Grand Sts. Estimated cost $800,000. W. S. Ferguson & Co., 1900 Euclid Ave., Cleveland, Ohio, Archts.

Mo., Kirksville—The city plans election February 9 to vote $325,000 bonds for improvements to water-works. Black & Veatch, Mutual Bldg., Kansas City, Mo., Engrs.

Mo., St. Louis—The Bd. Pub. Service will receive bids until Feb. 13 for alterations and additions to the hospital building of the City Sanitarium, including installation of a steam heating system, piping and radiation, $3,000.

Neb., Omaha—The Bd. Educ. is in the market for belt driven air compressor, capacity 6 cu.ft. per min. under 300 lb. pressure.

Neb., Omaha—The Lincoln City Hospital Assoc., c/o J. L. Teeters, Chn., 1812 D St., Lincoln, is having plans prepared for the construction of a hospital and power house here. Davis & Wilson, 515 Security Bldg., Lincoln, Archts. O. H. Bartine, Aeolian Bldg., New York, Consult. Archt.

N. Y., Brooklyn—C. Groell, c/o Shampan & Shampan, Archts., 188 Montague St., is having plans prepared for the construction of a 6 story, 100 x 175 ft. apartment building on St. Johns Place. Estimated cost $600,000. Equipment detail not reported.

N. Y., Jamestown—Hotel Jamestown, Inc., Cherry St., plans the construction of a 10 story hotel on 3rd and Cherry Sts. Estimated cost $1,225,000. W. L. Stoddart, 9 East 40th St., New York, Archt. Noted Nov. 28, 1922.

N. Y., Kenmore—School Dist. No. 1, 69 Tremaine Ave., purchased site and plans the construction of high school on Delaware Rd. Estimated cost $500,000.

N. Y., New York—The Bd. Educ., 500 Park Ave., will soon receive bids for P. S. 60, including steam heating system, on East 12th St. Estimated cost $850,000. C. B. J. Snyder, Flatbush Ave. Ext. and Concord St., Bklyn., Archt. and Engr.

N. Y., New York—The Libby's Hotel & Bath Corp., 126 Delancy St., is having plans prepared for the construction of a 15 story hotel on Delancy and Chrystie Sts., Estimated cost $2,600,000. Gronenberg & Leuchtag, 450 4th Ave., Archts. and Engrs.

N. Y., Perry—The Depew Light, Power & Conduit Co. plans the extension of its light and power lines to towns of Cowlesville, Bennington, Strykersville, Java, Curriers, etc. Estimated cost $25,000.

N. Y., Rochester—A. S. Di Paulo, 456 State St., is in the market for a vertical boiler to pass A.S.M.E. code and 10 hp. or larger.

N. Y., Watertown—The Northern New York Utilities, Inc., S. D. Gilbert, Mgr., Light & Power Bldg., is receiving bids for the construction of a new retort house, including equipment, at its gas plant on Engine St. Estimated cost $250,000.

N. C., Concord—The city plans enlargement of present water supply, including the construction of small dam and pipe line, and the installation of pumps, etc. Estimated cost $200,000. Mees & Mees, Kinney Bldg., Charlotte, Engrs.

N. C., Hickory—The Yeager Mfg. Co., Inc., M. Yeager, Secy., wants prices on woodworking machinery, including finish spraying machines, dry kiln equipment and electric motors.

Ohio, Bellefontaine—The Citizens' Ice & Supply Co. will receive bids about Mar. 1 for an ice and cold storage plant. Estimated cost $85,000. J. H. Meyer, Archt.

Ohio, Cleveland — The Garden Court Realty Co., G. A. Grieble, Pres., 517 Sloan Bldg., is having plans prepared for the construction of two apartment buildings, including steam heating systems, at 7338 Euclid Ave. Estimated cost $1,000,000. G. A. Grieble, Archt.

Ohio—Elyria—The Hart-Cookston Rubber Co. is in the market for 100 hp. boiler and 75 to 100 hp. gas engine.

Ohio, Willoughby — The village will receive bids until Feb. 12 for the construction of substructure for a 7 x 28 ft. pump house and the installation of two 210 gal. per min. centrifugal pumps. Estimated cost $15,000. R. E. Garvin, Davis & Farley Bldg., Cleveland, Engr.

Okla., Guthrie—The city will receive bids until Feb. 9 for waterworks extensions, including 13,000 ft. of 4 to 6 in. c.i. pipe and 6,000 ft. of 12 to 15 in. rein.-con. pipe. Estimated cost $40,000. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engrs. A 1,500 g.p.m. centrifugal pump driven by high speed marine engine will be installed.

Ore., Albany—The Mountain States Power Co., F. Brown, Mgr., plans extensions and improvements in southern Oregon during 1923, including waterworks, gas plants at Eugene and Marshfield, and the installation of electrical equipment for power line extending from Prospect to Springfield.

Pa., Harbour Creek—The Yerkes Steel Coupling Tie Co., W. H. Yerkes, Pres., c/o W. Kraemer farm, plans the construction of a 40 x 100 ft. plant for the manufacture of steel ties. Architect not announced. Owner is in the market for machinery and equipment, including electric melting furnaces.

Pa., Lancaster — The Lancaster Steel Products Corp. plans the construction of a 90 x 160 ft. warehouse, including the installation of three 2 ton motor traveling cranes, 30 ft. span each, four 2 phase, 60 cycles, 220 volt. J. J. Stunzi, Engr.

Pa., Merion—A. Barnes is having plans prepared for the construction of a 2 story art museum. Estimated cost $3,000,000. P. E. Gret, 1535 Chestnut St., Phila., Archt. Equipment detail not reported.

Pa., Phila—F. W. Easby, Engr., Crozier Bldg., will soon receive bids for the construction of 1 and 3 story textile mills, on 68th St. and Greenway Ave., for the Beswick & Clay Co., Inc., 25th and Callowhill Sts. Estimated cost $500,000. Owner is in the market for spindles, dyeing machinery, belting, etc.

Pa., Phila.—The Lincoln Drive Apartment Assoc., c/o L. H. Cahan, Walnut and Broad Sts., plans the construction of a 14 story, 52 x 208 ft. apartment building, with two wings, on Lincoln Drive and Johnson St. Estimated cost $2,500,000. Kennedy & Johnson, Harrison Bldg., Archts.

Pa., Pittsburg—Muhphy & McGrew, 613 Pittsburg Life Bldg., are in the market for a 165 hp. Bessemer engine.

Pa., Scranton—The Fairmont Creamery Co., 30 Tocka Ave., plans the construction of a dairy plant on 6th Ave. Estimated cost $48,500. Owner is in the market for dairy plant machinery and equipment, including conveying machinery.

Pa., Scranton—The Scranton Coal Co., Bd. of Trade Bldg., is in the market for coal machinery and equipment for new vein at Keyser Valley.

S. C., Spartanburg — The Pacific Mills, Inc., Lawrence, Mass., are in the market for machinery and equipment for $2,000,000 bleaching and finishing plant, here.

Tenn., Manchester—J. H. Ashley is in the market for a complete 10 ton ice plant (used, in good condition).

Tenn., Memphis—The H. Smith Heating Co., 220 East Court Ave., is having plans prepared for the construction of a 2 story office and warehouse building, including mechanical equipment for heating and ventilating, on Adams Ave. Estimated cost $5,000. H. J. Kramer, Goodwyn Institute, Archt.

Tenn., Springfield—The city council, W. H. Sprouse, Mayor, plans addition to electric light and power plant. Estimated cost $30,000.

Tex., Dallas—The Dallas Trunk Factory, 1005 Main St., is in the market for a power leather working machine for making patches.

Tex., Katy—A. E. Thompson is in the market for a 70 hp. gas engine.

Va., Prince George—J. E. Cousins, Jr., is in the market for upright engines of various sizes, tanks and towers.

Wis., Elkhorn—Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, are receiving bids for boiler feed pump and motor driven centrifugal brine pump for the Wisconsin Butter & Cheese Co. Noted Aug. 8, 1922.

Wis., La Crosse—The Lutheran Hospital Assoc., c/o F. Techner, Chn., 1243 Jackson St., is having plans prepared for the construction of a 2 story power plant on Front St. Estimated cost $125,000. O. E. Merman, Linker Bldg., Archt. Power machinery, including 3 boilers will be installed.

Wis., Madison—M. B. Allison, 315 Beaver is in the market for a complete ice plant.

Wis., Madison—P. Dean, Archt., Dean Bldg., is in the market for laundry equipment, including dryers for proposed apartment building.

Wis., Madison—The Hotel Madison Co., E. Clarenbach, Pres., 201 Wisconsin St., Milwaukee, is having revised plans prepared for a 6 story, 66 x 120 ft. hotel on Fairchild and West Washington Sts., here. Estimated cost, $400,000. C. Bardhausen, 79 Wisconsin St., Milwaukee, Archt. Noted Dec. 12, 1922.

Wis., Marshfield—I. Jones, 110 West North Depot St., is in the market for power machinery, belting and shafting, for creamery.

Wis., Milwaukee — Heinl & Sperry, F. Heinl, Purch. Agt., 171 Bway., is in the market for power candy making machinery.

Wis., Milwaukee—G. Ladwig, 668 American Ave., is in the market for window frame pocket and pulley machine, motor driven.

Wis., Milwaukee—The National Distilling Co., 79 Buffalo St., is in the market for refrigeration and conveying machinery.

Wis., Milwaukee—S. Schmidt, 200 Hadley St., is in the market for portable sawing outfit, gasoline engine or motor power.

B. C., Kamloops—Bond, Tucker & Goodwin, 65 Bway., New York, plan the construction of a city light and power plant and power plant for mines, etc., on the Adams River, here. Estimated cost $1,000,000.

B. C., Vancouver—The Dominion Government and Harbor Comrs., 712 Pender St., W., plans addition to grain elevators at the Government Elevator Docks, 1,000,000 to 1,250,000 bbls. capacity. Estimated cost $1,000,000 to $1,500,000. Architect not selected. Cleaning and conveying machinery will be required.

Ont., Ft. Erie—The town council, A. Seaton,, Clk., is in the market for generators and other equipment for addition to electric light and power plant.

Ont., Jarvis—P. W. Armstrong, is in the market for equipment for butter making and cold storage plant. Estimated cost $35,000.

Ont., North Bay—The town council, W. N. Snyder, Clk., Town Hall, plans to purchase and install gasoline pump, 3 stage, centrifugal, 1800 Imperial gal. per min. capacity.

Ont., Ottawa—The Ottawa Auditorium, Ltd., c/o Milson & Burgess, Archts., Sparks St., is having plans prepared and will soon receive bids for the construction of an auditorium, including stores and artificial ice rink, on O'Connor St. Estimated cost $225,000. Owner is in the market for an artificial ice plant for rink.

Que., Montreal—Will & Baumer Candle Co., Ltd., 330 Notre Dame East, J. Baumer, Purch. Agt., is in the market for a 15 hp. steam boiler.

H. T., Pearl Harbor — The Bureau of Yards & Docks, Navy Dept., Wash., D. C., received bids for a refrigerating and ice making plant, here, from Walker Olund, 820 Pukoi St., Honolulu, $18,796; Vilter Mfg. Co., 935 Clinton St., Milwaukee, Wis., $17,670; Shipley Constr. Co., 42nd and 2nd Aves., Brooklyn, N. Y., $35,125. Spec 4735. Noted Oct. 24, 1922.

Cuba, Havana—J. McE. Bowman, Hotel Biltmore, New York, is having plans prepared for the construction of a 10 story hotel. Estimated cost $5,000,000. Schultz & Weaver, 17 East 49th St., New York, Archts. and Engrs.

CONTRACTS AWARDED

Calif., Long Beach—The El Bolivar Holding Co., c/o Milton Realty Co., awarded the contract for the construction of a 12 and 14 story store and hotel building, to the Heitmen Constr. Co., Merritt Bldg., Los Angeles. Estimated cost $1,250,000. Equipment detail not reported.

Calif., Los Angeles—The Davenport Corp., c/o H. H. Whiteley, Archt., 520 South Western Ave., awarded the contract for the construction of a 7 story hotel, including ice making plant and garage, on Hollywood Blvd. near Carlos St., to the Heitman Constr. Co., Merritt Bldg. Estimated cost $2,000,000.

Ill., Chicago—The Bd. Educ., 650 South Clark Ave., awarded the contracts for the construction of 3 story, 208 x 266 ft. school at 4400 Sacramento Ave., to the A. & E. Anderson Co., 10 South La Salle St., also a 3 story, 92 x 108 ft. school addition on 16th and South Avers Ave., to G. Kehl & Sons, 1225 North Maple Ave. Estimated cost $650,000 and $500,000 respectively. Steam heating systems will be installed.

Ill., Evanston—V. C. Carlson, Archt., has been awarded the contract for the construction of a 7 story, 120 x 211 ft., apartment hotel on Orrington Ave. and Church St., $2,000,000. Noted Jan. 31, 1922.

Mo., St. Louis—A. A. Wagner, 5628 Delmar Blvd., awarded the contract for the construction of a 7 story, 48 x 190 ft. apartment hotel on Clara Ave., to F. L. Cornwell, La Salle Bldg. Estimated cost, including equipment and furnishing, $500,000. Noted Dec. 26, 1922.

N. J., Camden—The Victor Talking Machine Co., Front and Cooper Sts., awarded the contract for the construction of an 8 story, 70 x 435 ft. new plant and a 2 story 90 x 230 addition, to Stone & Webster, 120 Bway., New York. Estimated cost $1,300,000. Equipment detail not reported.

N. Y., New York—The Joint Ownership Constr. Co., Inc., F. Culver, Pres., 342 Madison Ave., awarded the contract for the construction of 15 story, 110 x 111 ft. studio apartment building at 424 East 57th St., to the Hegeman-Harris Co., Inc., 185 Madison Ave. Estimated cost $1,750,000. Equipment detail not reported.

N. Y., New York—The Transit Comm., G. McAneny, Chn., 49 Lafayette St., awarded the contract for the construction of transformer closets for emergency lighting for part of Broadway-Fourth Avenue Rapid Transit Railroad, to B. T. & J. J. Mack, 200 Bway. Noted Jan. 23.

Okla., Oklahoma City—The city, A. S. Holway, Supt. Water Dept., awarded the contract for an 8,400 gal. per min. centrifugal pump, to the N. S. Sherman Machine & Iron Works; a 5,600 gal. per min. centrifugal pump, to the Allis-Chalmers Mfg. Co., West Allis, Wis.

Okla., Tyrone — The city awarded the contract for waterworks improvements to the Ajax Constr. Co., 1825 West Main St., Oklahoma City. $61,534. Fairbanks-Morse engines, centrifugal pumps and electric motors will be installed. Noted Oct. 17, 1922.

Pa., Phila.—The Philadelphia & Reading R.R. Co., H. A. Cassil, Ch. Engr., Reading Terminal, awarded the contract for the construction of power plant, thawing house, 900 ft. pier and the installation of a 120 car dumping machine, to the McMyler-Interstate Co., Stop 27 A.B. and C. Electric Ry., Bedford, O., $1,500,000.

S. D., White Lake—The city awarded the contracts for sewer system, disposal plant and pumps to O. N. Gjellefald, Forest City, Ia., about $24,000; waterworks, (except pumps), including 50,000 gal. elevated tank on 100 ft. tower, pumping station and 100,000 gal. reservoir, to J. S. Harrington, 3001 Mason St., Omaha, Neb. Noted Jan. 9.

Wis., Milwaukee—Gimbel Bros., 3 Grand Ave., awarded the contract for the construction of an 8 story addition to department store, consisting of 3 units, 77 x 120 ft., 50 x 177 ft. and 42 x 175 ft. each, to W. W. Oeflein, 86 Michigan St. Estimated cost $800,000 to $1,000,000. Noted Jan. 9.